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# Nonlinearities in the oil fluctuation effects on the sovereign credit risk: A Self-Exciting Threshold Autoregression approach

**Saker Sabkha<sup>1</sup>, Christian de Peretti<sup>1</sup> and Dorra Hmaied<sup>2</sup>**

<sup>1</sup> Univ Lyon, University Claude Bernard Lyon 1,  
Institute of Financial and Insurance Sciences,  
LSAF-EA2429, F-69007, Lyon, France

<sup>2</sup> Univ of Carthage, Institute of High Commercial Studies,  
LEFA, Tunis, Tunisia

## Abstract

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The unquenchable thirst of several sectors to crude oil in the recent years makes a common belief regarding its key role towards the acceleration of the recent economic recession and financial instability. This paper aims to examine the nonlinear impact of oil shocks on the sovereign credit risk for a sample of 38 worldwide oil-producing and oil-consuming countries, over a period ranging from January 2006 to March 2017. In contrast to the existing literature, CDS volatility is employed as a measure for the creditworthiness level, rather than the commonly used CDS spreads first-order moment. The methodological framework used in this paper goes beyond previous studies and takes into account more financial data features (long memory behavior, asymmetric effects and nonlinearities) according to a self-exciting regime switching model. Results reveal some dissimilarities in the explanatory power of the exogenous variables between regimes and across countries. Particularly, restricted evidences of the impact of oil shocks on sovereign CDS volatility are detected during the stable regime, whilst during the risky regime credit volatility becomes more sensitive to oil market conditions for most of the studied countries. Overall, the decline in oil price worsens the public finances tenability whether the country is oil-related or not.

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*JEL classification* : G1, G15, E44.

*Keywords* : Sovereign CDS volatility, Oil market, FIAPARCH, SETAR, Threshold regime-switching.

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## Abstract

The unquenchable thirst of several sectors to crude oil in the recent years makes a common belief regarding its key role towards the acceleration of the recent economic recession and financial instability. This paper aims to examine the nonlinear impact of oil shocks on the sovereign credit risk for a sample of 38 worldwide oil-producing and oil-consuming countries, over a period ranging from January 2006 to March 2017. In contrast to the existing literature, CDS volatility is employed as a measure for the creditworthiness level, rather than the commonly used CDS spreads first-order moment. The methodological framework used in this paper goes beyond previous studies and takes into account more financial data features (long memory behavior, asymmetric effects and nonlinearities) according to a self-exciting regime switching model. Results reveal some dissimilarities in the explanatory power of the exogenous variables between regimes and across countries. Particularly, restricted evidences of the impact of oil shocks on sovereign CDS volatility are detected during the stable regime, whilst during the risky regime credit volatility becomes more sensitive to oil market conditions for most of the studied countries. Overall, the decline in oil price worsens the public finances tenability whether the country is oil-related or not.

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## 1. Introduction

Because of its highly required usage in countries' economic development, and considering the sharp increasing uncertainty around the role played by the credit market in the accentuation of the financial instability, academic and non-academic researchers are more and more interested in understanding the main drivers of the credit risk, approximated notably by the Credit Default Swap (CDS, hereafter) spreads. As the CDS market does not only reflect the creditworthiness but also quantifies the degree of investors' risk aversion and gives an insight on the systemic risk transfer, studying the credit risk determinants is widely useful for worldwide regulators and market participants so they can detect the risk source and properly adjust the policy-decisions during extreme situations. This paper aims to investigate whether the oil fluctuations can help to explain sovereign CDS conditional volatility, after controlling for local and global economy-wide factors.

Several papers exist in literature regarding the determinants of the corporate and sovereign credit risk. Using various economic and financial variables, authors mainly show that the country's creditworthiness depends on local and global economy-wide factors [1, 2, 3, 4, 5, 6]<sup>1</sup>. If studies on macroeconomic factors and their impact on credit risk multiply, a relatively few of them get interested into the potential role of the energy sector conditions in the determination of the sovereigns' solvency level. This might be due to the fact that oil prices were generally stable until recently when prices start to exhibit some volatile behavior. The strand of literature related to the purpose of our paper remains relatively limited and includes only few studies. On the one hand, [7] and [8] find a significant linear relationship between oil price and the investors' apprehension of sovereign credit risk. On the other hand, results of the quantile regression and the causality-in-quantiles approaches [9] and rolling-window cau-

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1. Only some recent references, investigating the variables that influence the level of CDS spreads, are cited here as examples. For a more exhaustive list, please refer to the literature review in section 2.

sality approach and the cross-quantilogram approach [10] analyzes show some asymmetric nonlinearities in the risk transfer between the oil market and the sovereign CDS market.

Our contribution to the existing literature is threefold. First, as far as we are concerned, this study is the first to give an in-depth investigation on the relationship between the oil fluctuations<sup>1</sup> and the sovereign credit risk, using not the CDS spreads as an indicator of the creditworthiness but rather the CDS volatility. In fact, using the volatility of CDS as a measure of credit risk seems to be more appropriate than its first-order moment for several reasons : On the one hand, initially developed to hedge governments' debts, CDS spreads were closely related to the default probability of a reference entity and their values seemed therefore suitable to measure how risky a country is. However, as time goes on, naked CDS are becoming to be increasingly used for speculation, which makes their spread levels dissociated from the inherent credit risk degree. Using sovereign CDS in a gain-making vision can have perverse effects as was the case during the recent sovereign debt crisis. In the case of Greece in particular, investors were betting on an increase in the country's probability of default by massively buying Greek CDS (even if this anticipation is not justified), leading thus to raise the spreads levels. In doing so, the price of protections on Greek debt effectively increased because of the increased demand on the market. Greece has therefore been subject to higher interest rates because of this speculative mechanism rather than because of its public finances deterioration. In our point of view, CDS spreads seem, therefore, to be a controversial measure of risk for investors, since high spreads do not necessarily imply a high probability of a credit event but rather a high volume of speculation. On the other hand, we believe that solvency risk should not be limited to the government's default probability, but should also take into account market instability and uncertainty about the investors' risk perception. The objective is thus to measure this "complementary" market risk in order to properly assess countries' creditworthiness.

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1. As detected in the price and in the volatility

Our reasoning is all the more legitimate since a certain paradox is observed during the first half of 2011 as regards the evolution of French CDS. During this period, CDS spreads – reaching 190 basis points – outpaced those of some much riskier countries like Brazil or the Philippines, despite the improvement in France’s credit conditions and the decline in its bonds’ interest rates. This increase in French spreads, notwithstanding the good health of the country’s fundamentals and notwithstanding the fact that French debt is still sought by investors, seems to be rather related to a high liquidity caused by rumors about the deterioration of the France sovereign rating. Therefore this situation reflects the limits of CDS spread as a measure of credit risk, especially in periods of high risk aversion and permanent rumors. In a nutshell, CDS spread represents the investor’s perception of the default probability; while CDS volatility represents the perception of the uncertainty around this probability and constitutes thus a complementary – but not substitute – risk measure.

Second, we use a novel methodological framework that considers simultaneously for several statistical features characterizing the CDS market such as the volatility clustering, long memory behavior, asymmetry and nonlinearity. Third, our time period spans over a relatively long interval covering the recent two financial crises and the precipitous fluctuations in oil prices by half of 2014. Yet, the current study includes several countries with different financial characteristics (not only highly oil-related countries), notably the less-studied countries in which oil price has outwardly no effect on the economic health.

The empirical findings show that the countries under study react in a heterogeneous way to economic and financial shocks and a regime-switching behavior is observed over time. Particularly, positive changes in oil market conditions negatively impact the sovereign CDS volatility for most cases, especially during the high-risk period (*2<sup>nd</sup>* regime), while limited evidence of significant relationship between these two markets are found during the stable regime. Our results confirm that the oil price is another relevant driving force of public finances tenability and thus an appropriate factor to be considered in the appreciation of sovereign credit risk for both oil-producing and oil-consuming countries.

The rest of the paper is structured as follows. An overall review of the literature studying the determinants of credit risk is presented in section 2, with a particular emphasis on papers dealing with the impact of oil price. section 3 presents a brief description of the potential risk factors and the methodological framework. Results are presented in section 4, while section 5 discusses the empirical findings. Concluding remarks are presented in section 6.

## 2. Literature review

Empirical papers investigating the key determinants of the CDS spreads can be divided into two categories depending on whether the reference entity is a company or a sovereign state. We start this section by an overview of the major studies belonging to these literature strands. Then, we provide a survey on the few papers particularly analyzing the impact of oil price on the CDS spreads fluctuations.

### 2.1. Corporate CDS analysis

Inspired by Merton's theoretical model, several authors empirically develop and assess companies' credit risk, using different methodological frameworks and econometric tools. From the early ones, [11] use monthly industrial bond to show that surprisingly the logical theoretical determinants don't impact the fluctuation of credit spreads. Based on the results of a principal component analysis, no significant explanatory power is detected from macroeconomic and financial variables and liquidity proxies. Credit risk spreads depend only on the local supply and demand shocks. At the opposite and based on a linear regression framework, [12] use a large set of explanatory variables to study the determinants of CDS premiums. Authors argue that the majority of the credit-risk fundamentals (credit rating, riskless interest rate, volatility, maturity and slope of the yield) significantly explain credit spreads. Similarly, using a simple linear regression of CDS spreads on some theoretical credit-risk factors, [1] present some empirical evidence of the significant role played by corporate leverage, volatility and risk-free rate in default-risk premium determination.

[13] investigate the role played by firm-level features and macroeconomic variables in the corporate credit spreads pricing. Results show that investor sentiment and the cash-flow volatility are the most important factors in explaining CDS spreads. Using a Markov-switching model, [2] also finds that the iTraxx Japan CDS spreads changes are explained by stock market and macroeconomic characteristics with a strengthening of these relationships during the crisis period. Having the same purpose, [14] focus on the credit risk of 32 European banks' debts. The major result obtained from this study shows that the explanatory power of the liquidity component, the bank-level variables and market factors is constantly changing over time and across the studied banks.

More lately, [15] analyze the determinants of CDS spreads of 718 US companies from 2002 to 2003. Through linear regression estimation, these authors show that common factors have a significant role in the spreads' formation only after taking into account the firm-specific variables. The authors find, furthermore, that three factors play the dominant role in the explanation of the corporate credit risk, namely, the stock returns, the stock market volatility's changes and the market conditions. Focusing their analysis on North America area, [16] study the factors explaining the corporate credit risk of two CDX categories (investment grade and high-yield). Based on a Markov-switching analysis, the results confirm that several macroeconomic variables significantly explain daily CDX spreads changes with a reinforced relationship during turmoil crisis periods. Market sentiment and liquidity proxies (market default premium and VIX) positively impact the risk spread while interest rate and financial factors (stock index returns and Fama-French-Cahart momentum factor) have a negative impact.

[17] go beyond the common research context and investigate the prediction ability of some pricing models developed in the literature. Even though these models are empirically proved to explain CDS spreads, the authors show that this is not always true when it comes to the forecasting performances of the iTraxx European index based on linear and non-linear techniques. Finally, using a data sample composed by emerging and developed countries, [18] show,



through an event-study analysis, that CDS trading initiation<sup>1</sup> is significantly affected by country-specific volatility index, regional and international CDS indexes, currency exchange rates and the percentage of external debt.

## *2.2. Sovereign CDS analysis*

Initially overlooked by investors, the sovereign credit risk has been reassessed upward since the 2000s which has contributed to awaken the interest of researchers in the determinants of sovereign CDS spreads. [19] are amongst the first authors to be interested in the pricing of sovereign credit risk. These authors focus on the Brazilian economic crisis of 2002 and use sovereign CDS data to show that the pricing of these credit spreads is mainly dependent on the underlying bond's recovery rate. [3] provide further evidence on the determinants of credit spreads changes using sovereign bonds. Authors show that before the outbreak of the Global Financial Crisis, prices on the credit market are driven by the domestic factors, while after the 2007, credit spreads are rather determined by macroeconomic variables and global risk factor. Similarly, and by considering the fact that CDS time series exhibit volatility clustering properties, [20] examine the CDS spreads changes of 12 emerging countries from different geographical regions. The authors find that during crisis period the commonly studied global factors have the most important role in the CDS price formation.

Using a simple regression analysis, [21] show that China's CDS spreads, in level and first difference, are explained by financial drivers in both country and global levels. The study is conducted over a period running from 2001 to 2010 and is interested in the sensitivity of spreads to the local stock market index, the real interest rate, the government foreign debt, the GDP, the total reserves, the VIX and the non-North America global index among other variables. [22] conduct the same analysis on 31 developed and emerging countries during the European debt crisis. The estimation results of a standard panel model with

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1. CDS trading initiation refers to the CDS spreads quoted at the first appearance of the reference entity.

fixed effects show that countries fundamentals are the main drivers of the sovereign risk and that these factors' explanatory power is accentuated during this crisis period. Besides the macroeconomic variables abundantly studied in the literature, [23] include two ratios (sovereign debt/tax revenue and fiscal deficit/tax) in their CDS pricing model as proxies for fiscal space. Authors show that fiscal space is not only important in explaining European credit risk but also in predicting sovereign CDS spreads.

[24] goes beyond the fundamental determinants of credit spreads studied in the literature and gets interested in the political context and its impact on the sovereign bond yields. Results show that sovereign spreads of the presidential regimes' countries are less than those in parliamentary countries. Political stability is found to play a significant role in the credit prices' formation while the degree of democracy has no impact. Using a panel cointegration framework on bond spreads of 9 Euro-area countries, [4] argue that the main components of the credit yields are the fiscal imbalances, the liquidity premiums and the cumulated inflation differentials. Authors also show that these results are drawn only for countries not belonging to the Optimal Currency Area.

Whether represented by the CDS spreads or the bond spreads, [5] show that the sovereign risk is mostly explained by common drivers such as the riskless rate, the risk aversion level, the corporate CDS index defined by the iTraxx, the total government debt and the stock market volatility. Using a vector autoregression framework over a period spanning from 2001 to 2010, [6] find evidence of significant unidirectional relationship from the VIX, the currency exchange rate and the bond to the CDS spreads. Besides the country-specific factors (the currency rate and the bond yield), the VIX has the most important role in reducing predicting errors.

More recently, [25] uses quarterly data of 8 emerging countries from 2008 to 2013 to distinguish between the CDS spreads determinants in short-term and in the long-term. Results of panel cointegration estimation reveal that three local economic indicators (current account, foreign debt and international reserves) are the main drivers of sovereign risk with the most important role played by

international reserves. The author also shows that an increase in these fundamentals improves the government's solvency and reduces, thus, the sovereign spreads. However, this cointegration relationship is not statistically significant in the short-run for all countries. At the opposite, [26] find that local macroeconomic factors have low impact on the spreads formation of 5 Euro-area countries. These authors show, on the other hand, that global factors, and more particularly European Monetary Union factors, play a predominant role in the pricing of the CDS changes.

### *2.3. The impact of oil prices on the CDS spreads*

Because of the sharp uncertainty about the energy sector fluctuations during recent years, researchers are more and more interested in the interaction between the energy market and the credit market either in a bivariate framework or by incorporating oil price as a global-wide explanatory variable in the credit risk pricing models. [27] are the first authors to study the shock transmission between the credit default swap market and the energy market through a regime-switching Vector Autoregressive context. Using data from 2003 to 2009, the authors find, among others, that oil price and the stock price play the predominant role in explaining the North American DCX index fluctuation, especially during risk regimes. More particularly, [28] focus on the determinants of CDS spreads of US oil-related sectors from 2004 to 2011. The sectoral CDS index is found to have significant causal relationship with the VIX and the SMOVE<sup>1</sup> indexes.

[29] study the interaction between the corporate CDS market and the energy market from 2004 to 2013. Focusing on the joint behavior of the CDS energy sector index and CDS spreads of different credit rating categories with the light sweet crude oil futures contracts, and using a linear regression approach, the authors show that jumps in the volatility of these futures contracts have a significant impact on the CDS changes. These markets interact more during

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1. The swaption volatility index.

financial turmoil phases. Similarly, [30] examine the financial, economic and energy determinants of the US CDS index of three sectors, banking, financial services and insurance, over a period spanning from 2004 until 2014. Results of the NARDL methodology reveal asymmetries and nonlinearities between the three-month libor, the three-month Treasury rate, the federal funds rate, the VIX and the oil price and the CDS changes in both the short and the long-runs. [31] conduct the same investigation on the industry sector and base their analysis on a NARDL approach, as well, to capture asymmetries in the short and long-runs. These authors study a period spanning from 2007 to 2015 and find an asymmetric cointegrated relationship between the CDS spreads index of US industrial firms and the corresponding industry stock indices, the US stock market volatility, the 5-year treasury bond yields and the crude oil price.

Regarding the sovereign market, [9] examines the pricing of the CDS spreads of 16 countries from 2009 to 2016 using the most important financial and risk drivers, namely, the VIX, the 10-year US Treasury rate, the MOVE index<sup>1</sup>, the West Texas Intermediate (WTI) price and the OVX index. Based on the quantile regression and the causality-in-quantiles approaches, the analysis reveal a nonlinear relationship between the studied factors and the sovereign spreads, depending on the market state (bearish, bullish or normal). Moreover, results show that the oil price is the most important determinant of CDS spreads particularly in oil-exporting countries and that sovereign risk is more sensitive to bond market uncertainties than to stock market uncertainties. [10] study the pattern predictability of the risk transfer from the oil market to the sovereign CDS market. Using both rolling-window causality approach and the cross-quantilogram approach, these authors focus on the sovereign markets of 11 countries belonging to the Gulf Cooperation Council and to other oil-producing countries from 2009 to 2016. Results show that there is a directional predictability from the oil market to most of oil-exporting markets particularly during the crash of oil price.

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1. The MOVE index is the VIX's analogous on the bond market.

#### *2.4. Limits and contributions*

Most of the aforementioned studies investigating the impact of financial and macroeconomic factors on credit risk, use the CDS spreads as dependent variable to proxy the credit risk level, which does not seem totally relevant, at least if it is not associated with any other economic or financial indicator. In fact, this approach is based on the assumption of a risk-neutral market so the default probabilities can be properly reflected in the CDS spreads. However, in reality, economic agents are risk-averse, with different levels of aversion. They require therefore an additional premium that results in the overvaluation of CDS. Because of their risk-averse nature, investors may also request a counterparty risk premium linked not only to the reference entity but also to the default probability of the CDS seller itself. Finally, trading CDS for speculative purposes means that CDS spreads also contain a third bias related to the liquidity premium, which can lead to conflicting signals. For all these reasons, we propose in this paper an assumption in which using the volatility of CDS as a measure of credit risk is more appropriate than its first-order moment. Yet, studying the determinants of CDS volatility is still a sparse or at least an under-investigated financial issue<sup>1</sup>. Given the afore stated postulate, we are motivated to study the impact of some explanatory factors on the CDS volatility, with a particular emphasis on the impact of oil price and oil instability (volatility).

Some of the existence literature supposes a linear relationship between credit risk and oil price, using linear regression or an ARDL approaches, which ignores the fact that financial series clearly exhibit complex and nonlinear nature [28, 29]. This time series' joint characteristic is easily admitted since financial markets are highly unstable and crisis periods are frequently occurring, making CDS series subject to structural breaks, outliers and potential asymmetric ef-

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1. As far as we are concerned, the only paper taking into account the volatility of CDS spreads, while studying the credit risk determinants is presented by [20]. Although the authors use a GARCH framework, they still only interested into the sensitivity of CDS and CDS spread changes to international and local risk factors.

fects. To overcome these gaps, [30], [31] and [9] introduce the nonlinearity and asymmetries while studying the dynamics of CDS spreads. However, the adopted econometric approaches still neglect a prominent stylized fact of financial series, which is the long memory behavior. We use, in this paper, an extensive framework, that takes into account simultaneously long memory behavior and leverage effects, through a FIAPARCH model, and the nonlinearity of CDS volatility and the economic factors' asymmetric impacts, through a SETAR model.

### 3. Data and Methodology

This section presents the data sample and the financial and economic variables used as factors in the sovereign CDS spreads explanation. Then, the cubic spline interpolation methodology used to convert quarterly and monthly time series into daily is introduced. Lastly, the econometric framework, including the FIAPARCH volatility model and the SETAR model, is as well displayed in this section.

#### 3.1. Sample and variables description

The studied sample in this paper is composed by some of the world's 25 biggest oil-producing countries and other worldwide countries belonging to different economic categories (developed countries, newly industrialized countries and emerging countries) and different geographical areas (Eastern Europe, South and Central America, Asia and Western Europe), leading to a total dataset of 38 countries. Table 1 presents the countries' sample with their economic and geographical status.

TABLE 1: Countries classification

	<b>Country</b>	<b>Economic Status</b>	<b>Geographical position</b>
<i>Oil-producing countries</i>	Norway	<b>Developed countries</b>	Western Europe
	UK		Western Europe
	USA		North America
	Brazil	<b>Newly industrialized countries</b>	South America
	China		Asia
	Mexico		North America
	Qatar		Asia
	Thailand		Asia

	Indonesia		Asia	
	Russia	<b>Emerging countries</b>	Asia	
	Venezuela		South America	
<i>Other worldwide countries</i>	Austria		Western Europe	
	Belgium		Western Europe	
	Denmark		Western Europe	
	Finland		Western Europe	
	France		Western Europe	
	Germany		Western Europe	
	Ireland		Western Europe	
	Italy		Western Europe	
	Japan	<b>Developed countries</b>	Asia	
	Latvia		Eastern Europe	
	Lithuania		Eastern Europe	
	Netherlands		Western Europe	
	Portugal		Western Europe	
	Slovakia		Eastern Europe	
	Slovenia		Eastern Europe	
	Spain		Western Europe	
	Sweden		Western Europe	
		Philippines	<b>Newly industrialized countries</b>	Asia
		Turkey		Asia
		Bulgaria		Eastern Europe
	Croatia		Eastern Europe	
	Czech		Eastern Europe	
	Hungary		Western Europe	
	Greece	<b>Emerging countries</b>	Western Europe	
	Poland		Eastern Europe	
	Romania		Eastern Europe	
	Ukraine		Eastern Europe	

The list of oil-producing countries is collected from the Monthly Energy Review (May 2017) of the US Energy Information Administration (EIA). Countries classification into these categories is made according to the NU, the CIA world Factbook, the IMF and the World Bank criteria.

Daily 5-year sovereign CDS spreads, Brent crude oil price and the other explanatory variables are extracted from Thomson Reuters ®. The studied period ranges from January 2<sup>nd</sup>, 2006 to March 31<sup>st</sup>, 2017, comprising 2936 observations. To our knowledge, the period considered is the longest and the most recent timeline among the CDS studies. The use of daily frequency seems to be more relevant than other frequencies since it provides a huge amount of information with a better capture of short and mid-range spreads movements.

The explanatory factors used as exogenous variables in the SETAR model are presented in Table 2. The use of these control variables is inspired by their potential explanatory power of credit risk level validated in the empirical literature. The first set of variables includes several financial and macroeconomic measures of the country's fundamentals, while the second set is comprised by global economy-wide factors to account for the international environment conditions. Note that the purpose of this paper is not to predict nor to explain credit spreads, but rather to investigate the sensitivity of credit risk to changes in oil market conditions, whether captured in the average oil price (return) or in the oil uncertainty (volatility), after controlling for some commonly used macroeconomic and financial factors.

Given that the literature considers the financial sector's health and the country's future prospects as key determinants of a country's creditworthiness [32, 33, 34, 35], we integrate among the regressors the national stock market index and the Thomson Reuters global index respectively as a country-specific explanatory factor and a common factor. The stock market index (Thomson Reuters global index) measures the value of the most locally (internationally) traded significant companies and allows to give an overall picture of the investor sentiment with respect to the local (global) economy financial health.

As an indicator of measuring the health of a country's economy, we use three macroeconomic variables, namely the nominal Gross Domestic Product (GDP), the government total debt and the government external debt. The reason behind this choice is that any variation in these measures, whether up or down, almost always has a significant impact on the country's creditworthiness and thus on the credit market conditions (See for example [36], [37], [38], [38]...). These constitute the primarily source of information for investors when assessing an investment strategy and for analysts when developing an economic policy regarding the country's related default risk.

We adopt as well a measure that is the sovereign bond yields to gage the default risk premium required by investors (The potential relationship between this measure and the credit risk has already been investigated by [39], [40], [5]



and many others). The rationale behind this choice is that a rise in the yields indicates an increase in the investor risk aversion and a deterioration the credit market conditions, which may impact the CDS volatility and thus the sovereign default risk.

Another indicator of the state of the government's public finances is also included using the Harmonized Consumer Prices (HICP-all items) ([41], [4], [42], [43], [44] and many others also explored the role played by this indicator of economic activity in explaining the credit risk). For example, [4] argue that investors may require additional risk premium if they observe persistent inflation, which leads to worsen the government's deficit and debt issues and thus its credit risk category. Whilst, [42] show that the inflation rate doesn't influence the country's ability and willingness to service its debt. Despite this divergence in the results regarding whether the inflation is a determinant of the credit risk or not, we do not exclude it from the regressors of our SETAR model.

Following [9], we use the VIX (the implied volatility of the S&P500 index) to control for the impact of the global financial market uncertainty on the sovereign credit risk. This measure has been also explored by [45], [46], [47] and so on to gage the effects of market risks on the sovereign creditworthiness.

Beyond the above-mentioned theoretical and empirical determinants that have been validated in the literature and used as control variables, our regressions incorporate as well the consumer confidence index (CCI) as a country-specific factor and the Brent crude oil price and the CBOE Crude Oil Volatility Index<sup>1</sup> as common factors. Regarding the CCI, it is used in this paper to control for the optimism/pessimism of the consumers toward the economic future. Including this factor in the model specification seems to be appropriate following the recommendation of the Organization for Economic Co-operation and Development (OECD) that considers it as a leading indicator : being optimistic

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1. The OVX measures the Chicago Board Options Exchange's expectation of 30-day volatility of crude oil prices. This measure uses the same estimation methodology as the VIX. It is used in this paper to proxy the oil market uncertainty, as in [10].

leads to more purchases and therefore to stimulate the whole economy, which improves the country's creditworthiness.

TABLE 2: Variables description

<b>Variables</b>	<b>Description</b>	<b>Expected relationship</b>
<i>Country-specific factors</i>		
SMR	Daily log returns of national stock market index.	Positive financial market performance should reassure investors about the market outlook regarding its financial stability. A negative relation is thus expected between stock returns and the country's default risk.
RBV	Daily log returns of sovereign bond yields.	An increase in the bond yield implies an increase in risk perceptions by investors which is expected to lead to a rise in the market volatility and thus the credit risk level.
RGDP	Daily log returns of the nominal Gross Domestic Product.	The economic expansion drives the diminishing of the future debt real weight which is expected to improve repayment ability and reduce the country's credit risk.
RDEBT	Daily log returns of the government total debt.	The more the debt burden is important, the more the economy is weak. A positive relationship is expected between the level of government indebtedness and the perceived default risk.
REDEBT	Daily log returns of the government external debt.	The level of foreign debt is expected to negatively impact the country's economic growth rate and thus its default probability. As the foreign debt is amplifying, the country international competitiveness is lessening.

INF	Daily log returns of the Harmonized Consumer Prices (HICP-all items).	No particular sign is expected for the relationship between inflation and the sovereign credit risk. In fact prices' increase may have different effects : Inflation was associated with economic growth during the 30 glorious years. However, during the 1970s a shift in the market reaction is observed (stagflation) due to economies' openness and international competitiveness harshness.
RCCI	Daily log returns of the Consumer confidence index.	If the CCI decreases, then investors upward their perception of the sovereign risk and may require higher loan interest rates, burdening the public borrowing cost. Thus, a negative relation is expected between the consumer confidence level and the sovereign risk level.
<b><i>Common factors</i></b>		
RTRGI	Daily log returns of the Thomson Reuters global index.	Stock returns are closely related to the economic growth and should thus negatively impact credit risk. So, the higher this index is, the less probably the default is expected to occur.
VIX	Daily volatility index based on the implied volatility of the S&P500 index options for the next 30 days.	The more this index is high, the more the uncertainty and risk aversion are observed on the global stock market. The VIX is thus expected to be positively correlated with the default likelihood.
RWTI	Daily log returns of the West Texas Intermediate Brent crude oil prices	-

Logically, a positive shock on oil price drives to a deterioration in the economic situation of oil-consuming countries, whilst this leads to an improvement in the financial and macroeconomic conditions of the oil-producing countries. In fact, an increase in oil price is expected to enhance the financial health, the public finances sustainability and thus the creditworthiness uncertainty of oil-related countries. Contrarily, a negative relationship is expected between oil shocks and the economic growth of oil-consuming countries, which implies that a rise in energy prices leads to weaken the ability of these countries to repay their debts and awaken investors credit risk aversion. In fact, the more the oil price is important, the more the import costs are high, the greater budgetary expenditures are and the more the country's public health is consistent – as reflected in the CDS spreads volatility. Finally, some statistically insignificant relationships should be observed between oil prices and CDS volatility of some countries that are not big producers of oil but are self-reliant with their oil needs. In these countries the government reimbursement ability is not or very little sensitive to oil fluctuations.

### *3.2. Data treatment : A cubic spline interpolation*

As larger frequency data improves estimation results in macroeconomic field [48], we use a daily interval time series data. Although our main data (CDS spreads and oil price) are directly extracted in the right frequency, some macroeconomic series are only available in monthly, quarterly or even annual frequency (GDP, Total debt, HICP . . .). We need, thus, to convert time series with lower frequency to the same time interval through one of the most commonly used method : the Cubic Spline Interpolation, following [49], [50] and [51].

This approximation technique allows us to get a smooth estimate of unknown observations. Between each two points, a piecewise continuous curve is drawn to

connect them, using a 3<sup>rd</sup> degree polynomial function. The detailed step-by-step method is presented in Appendix Annexe A.

### 3.3. Econometric models

The sensitivity of sovereign CDS volatility to oil market shocks (as detected in the price return and/or in the volatility) is investigated, through a two-step process : **(1)** A univariate FIAPARCH volatility models are fit for the CDS spreads series to obtain the conditional volatility  $\sigma_{i,t}$  of each market. **(2)** The estimated volatility is explained with regard to its own lagged values and local and global variables chosen from the literature. We use a nonlinear time series model that allows for regime-switching, so-called Self-Exciting Threshold Auto-Regressive (SETAR).

#### Step1. AR(1)-FIAPARCH(1,d,1) :

We employ the univariate FIAPARCH model as an estimator of CDS historical volatility. The use of such class of model is motivated by the work of [52], in which they show that the use of Fractionally Integrated Generalized Auto-Regressive Conditionally Heteroskedastic class of models instead of a standard GARCH model improves the conditional variance flexibility and takes account of more GARCH specifications in the volatility process. In order to model the CDS spread for each country, time series are assumed to follow an AR(1) process such as,

$$x_t = \ln(S_t) - \ln(S_{t-1}) = a_0 + a_1 x_{t-1} + \varepsilon_t, \quad (1)$$

with  $S_t$  denotes the CDS spread of a country from the sample at time  $t$ ,  $a_0$  is a constant,  $|a_1| < 1$  and  $\varepsilon_t = e_t \sigma_t$ , with  $e_t$  constitutes a white noise with  $E(e_{t-1}^2) = 1$ .  $\sigma_t^2$  is a positive parameter representing the conditional variance of  $x_t$  such as  $\sigma_t^2 = Var(x_t | \mathcal{F}_{t-1})$  with  $\mathcal{F}_t$  is the market information set at a given moment  $t$ .

The FIAPARCH model of [53] is estimated as follows :

$$\sigma_t^\delta = \alpha_0(1 - \beta)^{-1} + [1 - (1 - \beta(L))^{-1} \phi(L)(1 - L)^d](|\varepsilon_t| - \gamma\varepsilon_t)^\delta. \quad (2)$$

With  $0 < d < 1$ ,  $L$  is the lag operator and  $(1 - L)^d$  is the financial fractional differencing operator.  $\delta$  depicts the Box-Cox power transformation of the conditional volatility ( $\sigma_t$ ), and satisfies the condition of  $\delta >= 0$ .

The FIAPARCH is an extension of the conventional fractionally integrated GARCH model (FIGARCH) [54]. This new approach combines the long-range dependencies feature and the asymmetric impact of lagged positive and negative shocks on future volatility in one fractionally integrated model.

*Step 2. Self-Exciting Threshold Auto-Regressive (SETAR) :*

The CDS conditional volatility estimated from the FIAPARCH(1,d,1) is incorporated as a dependent variable in a short-run time series model, called a Self-Exciting Threshold Auto-Regressive model [55] with exogenous variables. The adoption of a regime-switching model seems to be useful and appropriate, since the oil price/uncertainty and the other control variables are not supposed to play a constant role over time, and may be subject to structural changes.

The two-regime SETAR model for a time series  $y_t$  with two-regime is written as follows :

$$y_t = \left( \omega_1 + \sum_{i=1}^k \theta_{1,i} y_{t-i} + \sum_{j=1}^n \Phi_{1,j} z_{j,t} + \xi_{1,t} \right) \zeta(y_{t-h} \leq \chi) + \left( \omega_2 + \sum_{i=1}^k \theta_{2,i} y_{t-i} + \sum_{j=1}^n \Phi_{2,j} z_{j,t} + \xi_{2,t} \right) \zeta(y_{t-h} > \chi), \quad (3)$$

with  $y_t$  is the estimated conditional volatility of the CDS spreads at time  $t$  ( $\hat{\sigma}_t$ ),  $k$  and  $n$  are respectively the lag order of the autoregressive process and the number of exogenous variables ( $z_t$ , among which we incorporate the price and volatility of oil in addition to some control variables) in the model and  $\xi_{m,t}$  are the residuals such as  $\xi_{m,t} \sim \mathcal{D}(0, \sigma_m^2)$  with  $m = \{1, 2\}$  represents the regime.  $\zeta(\cdot)$  is an indicative function that equals to 1 if the condition in parentheses is respected and 0 otherwise,  $h$  is the length delay and  $\chi$  is the threshold parameter chosen automatically by the numerical optimization based on the Broyden-Fletcher-Goldfarb-Shanno (BFGS) method [56].

The self-exciting model is more adequate because it considers more features of the volatility series than what is usually considered in conventional linear model : Unlike basic autoregressive models where the parameters are constant at any time,  $\omega_m$ ,  $\theta_m$ ,  $\Phi_m$  and  $\xi_m$  are allowed, in the threshold autoregressive model, to change between regimes and to have two values depending on whether the market is upward or downward.

Along with these lines, a self-exciting model is proposed to explain the volatility rather than the commonly used linear model for several reasons : (i) the nonlinearities of our volatility series are taken into account, (ii) the flexibility of the model regarding the parameters' behavior during the regime switching and (iii) the threshold variable is set as to depend on the past values of the dependent variable (the CDS volatility here).

We follow in this paper the three-step Tong's method [57] for estimating the SETAR model. Other methods exist in the literature as to the appropriate technique for estimating the model parameters (Hansen's method [58], Tsay's method [59]. . .) (See [60] for a detailed discussion on modeling SETAR based on these latter methods, for European GDP data and euro, dollar and Turkish pound exchange rates respectively). First, the relevant autoregressive level ( $k$ ) is determined by using the partial autocorrelation coefficients function (PACF). The lag order selection may also be done according to the AIC (or another information criterion), by supposing that  $h$  and  $\chi$  are constant, such as :

$$\hat{k} = \min\{AIC(y_k)\}, \text{ for } k = 1, 2, 3. \quad (4)$$

However, [59] argue that the presence of a non-linear dynamism in our estimated process makes information criteria irrelevant in selecting the autoregression order. Second, the threshold variable ( $y_{t-h}$ ), that leads to switch from one regime to another, is nothing but a lagged value of the dependent variable (conditional volatility here). The appropriate lag specification ( $h$ ) is assumed to be known (constant) while the threshold value ( $\chi$ ) is chosen automatically by using the information criterion AIC (the  $\chi$  parameter that minimizes the value of the

$AIC(h, \hat{\chi})$  is selected among all the possible threshold values), such as :

$$(\hat{h}, \hat{\chi}) = \min\{AIC(h, \chi)\}. \quad (5)$$

Third, after determining  $k$  and  $\chi$  values, the threshold variable's lag specification  $h$  is selected in such a way that minimizes the NAIC(h) criterion. According to [57], since the value of  $h$  will impact the number of observations ( $T$ ) in each sub-sample of the two regimes, using the NAIC criterion instead of the ordinary AIC criterion is more appropriate.

$$\hat{h} = \min\{NAIC(k, \chi)\}, \text{ with } NAIC = \frac{AIC}{T - T_h}. \quad (6)$$

Usually and following the recommendation of the Tong's method, we should use the information criteria to select the best fitted model. However, since the number of our model parameters isn't time-varying then, minimizing the sum of squared residuals (SSR) gives the same result as minimizing the information criteria. The  $h$  selection is therefore determined such as :

$$\hat{h} = \min\{SSR(k, \chi)\} \quad (7)$$

## 4. Results

### 4.1. Data analysis

Table 3 displays summary statistics on the oil price and the CDS spreads of each country. The mean value of the oil price is 76.90 USD over the 195 studied months. Figure 1 shows that the price of a barrel of crude oil reaches historical levels by the end of 2007 – probably due to strong demand and weakness of the dollar exchange rate. These reactions result from the increase in the investors' aversion after the appearance of the first signals of the US recession. Countries CDS spreads present dissimilar variability, with the maximum values recorded in Venezuela, Greece and Ukraine. The average CDS spread highly fluctuates from one country to another and doesn't seem to depend on whether the country is an oil-producer or not. CDS spreads exhibit high standard deviations, which indicates that the time series present several extreme values (This could be



explained by the fact that our studied period includes several financial turmoil that causes unusual changes, such as the enormous increases in CDS levels after the European sovereign debt outbreak.). Finally, the Augmented-Dickey Fuller test shows that the oil crude prices and the CDS spreads of each country are not stationary at 5% level, implying that the studied CDS series exhibit leptokurtic properties.

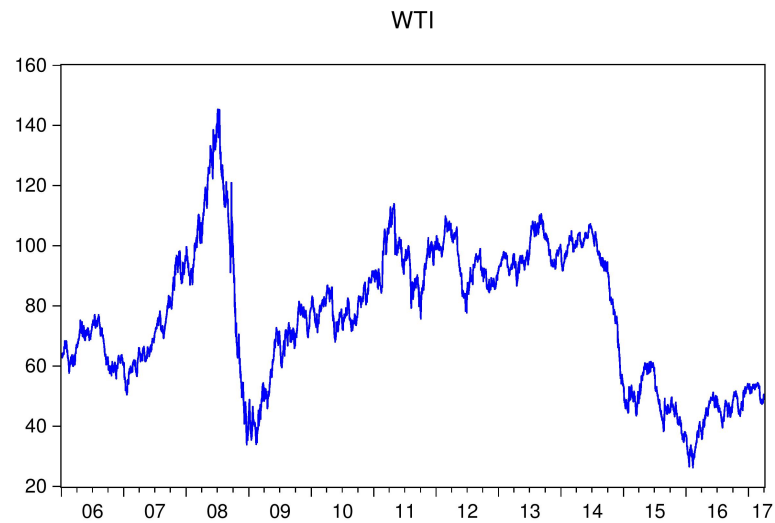


FIGURE 1: West Texas Intermediate oil price

As we need relevant statistics, the exogenous variables included in the SETAR have to be stationary as well. These time series properties are further investigated through the Augmented-Dickey Fuller unit root test (Results are presented in Table B.7, Appendix Annexe B). Results show that our explanatory economic and financial variables exhibit non-stationary behavior at least at the 5% statistical level, and need thus to be stationarized through the use

of mathematical techniques. For each country under study and each variable, daily returns are calculated following  $z_t = \ln\left(\frac{p_t}{p_{t-1}}\right)$ , with  $p_t$  is the variable value at time t. The logarithmic return transformation is used in this paper rather than the first difference because it allows for better suitability of time series' distributional characteristics.

TABLE 3: Descriptive statistics and non-stationarity tests of CDS spreads and oil prices

	Obs.	Min	Mean	Max	Std. Dev	ADF statistics
<b>Oil Price reference</b>						
West Texas Intermediate (WTI)	2936	26.21	76.90	145.29	22.96	-1.82
<b>CDS spreads</b>						
<i>Panel A : Oil-producing countries</i>						
Norway	2936	10.59	30.95	62.00	17.82	-1.68
UK	2936	16.50	42.89	165.00	28.11	-2.07
USA	2936	10.02	24.01	90.00	11.11	-3.58 *
Brazil	2936	61.50	178.55	606.31	94.86	-2.46
China	2936	10.00	82.44	276.30	43.56	-2.82 *
Mexico	2936	64.17	141.89	613.11	59.36	-3.03 *
Qatar	2936	7.80	83.13	390.00	53.89	-2.12
Thailand	2936	51.01	120.94	500.00	41.89	-3.64 *
Indonesia	2936	118.09	219.29	1240.00	116.83	-2.63 *
Russia	2936	36.88	209.09	1106.01	147.84	-2.95 *
Venezuela	2936	124.62	1771.08	10995.67	1869.79	-2.00
<i>Panel B : Other worldwide countries</i>						
Austria	2936	1.40	36.13	132.77	24.96	-2.45
Belgium	2936	2.05	72.39	398.78	74.62	-1.67
Denmark	2936	11.25	36.65	157.46	32.94	-2.17
Finland	2936	2.69	26.85	94.00	19.24	-2.33
France	2936	1.50	54.30	245.27	50.56	-1.71
Germany	2936	1.40	28.77	118.38	24.50	-2.05
Ireland	2936	1.75	188.89	1249.30	234.02	-1.36
Italy	2936	5.57	151.75	586.7	127.38	-1.79

Japan	2936	2.13	49.26	152.64	33.28	-1.94	
Latvia	2936	5.50	210.89	1176.30	216.13	-1.62	
Lithuania	2936	6.00	169.21	850.00	154.01	-1.90	
Netherlands	2936	7.67	37.13	133.84	29.50	-2.00	
Portugal	2936	4.02	289.89	1600.98	323.68	-1.60	
Slovakia	2936	5.33	77.52	306.01	66.71	-2.03	
Slovenia	2936	4.25	131.24	488.58	114.88	-1.65	
Spain	2936	2.55	144.63	634.35	135.01	-1.56	
Sweden	2936	1.63	27.17	159.00	25.70	-2.64	*
Philippines	2936	78.30	188.72	840.00	101.70	-1.77	
Turkey	2936	109.82	217.65	835.01	72.41	-3.72	*
Bulgaria	2936	13.22	180.37	692.65	121.88	-2.25	
Croatia	2936	24.88	244.20	592.50	128.47	-2.15	
Czech	2936	3.41	66.89	350.00	49.54	-2.62	*
Hungary	2936	17.34	225.98	729.89	153.05	-2.18	
Greece	2936	5.20	9508.85	37081.41	15351.1	-1.46	
Poland	2936	7.67	101.35	421.00	73.12	-2.32	
Romania	2936	17.00	204.20	767.70	144.17	-2.09	
Ukraine	2936	1.00	2173.76	15028.76	3969.28	-2.15	

The table reports descriptive statistics for the daily WTI oil price and CDS spreads expressed in basis points. Min., Max. and Std. Dev. denotes respectively to the minimum, the maximum and the standard deviation. The Augmented-Dickey Fuller (Individual intercept included in the test equation) is a stationarity test, with the null hypothesis is defined as the presence of a unit root in the process (non-stationary time series). \*, \*\* and \*\*\* refer to statistical significance at respectively 10%, 5% and 1%.

Results of the preliminary statistical tests on the CDS spreads log returns (Table 4) show that no time series is normally distributed, with the highest Excess Kurtosis values are observed for Ireland, Greece and Ukraine. Residuals are, thus, allowed to follow a Gaussian, a student and a Generalized Error Distribution (G.E.D). The Engle's ARCH-LM test with 2, 5 and 10 lag orders detects autocorrelations in the squared residuals and confirms the presence of ARCH effects in all the studied time series (Except for CDS of Greece). CDS spreads

also exhibit high persistence in volatility (Except for CDS of Greece), according to the results of the log periodogram test of [61]. The box plots, displayed in Figure 2, show that the median is in most cases not in the center of the box, indicating that the dataset is asymmetric. The use of FIAPARCH(1,d,1) model to estimate the dynamic conditional volatility – allowing for long-memory behavior and asymmetric effects – is, thus, justified.

TABLE 4: Preliminary tests on the CDS log-returns

	Skweness		Excess Kurtosis		Jarque-Bera	ARCH-LM (2)	ARCH-LM (5)	ARCH-LM (10)	GPH					
<i>Panel A : Oil-producing countries</i>														
Norway	-1.15	***	47.63	***	2.8E+05	***	3.22	***	2.46	***	2.06	***	0.05	**
UK	0.89	***	21.38	***	56263	***	27.33	***	21.12	***	23.19	***	0.11	***
USA	0.33	***	12.64	***	19581	***	94.96	***	46.67	***	24.57	***	0.18	***
Brazil	1.89	***	27.49	***	94159	***	25.01	***	43.70	***	37.71	***	0.11	***
China	0.67	***	33.49	***	1.4E+05	***	120.85	***	63.09	***	39.00	***	0.22	***
Mexico	0.20	***	35.65	***	1.5E+05	***	356.35	***	160.17	***	127.50	***	0.39	***
Qatar	1.38	***	32.85	***	1.3E+05	***	37.65	***	17.33	***	9.55	***	0.09	***
Thailand	0.63	***	24.38	***	72831	***	81.52	***	120.36	***	96.33	***	0.17	***
Indonesia	0.80	***	17.02	***	35720	***	139.82	***	105.31	***	61.49	***	0.23	***
Russia	0.69	***	20.97	***	54004	***	258.09	***	117.58	***	65.50	***	0.29	***
Venezuela	0.25	***	13.51	***	22350	***	36.17	***	38.56	***	22.73	***	0.11	***
<i>Panel B : Other worldwide countries</i>														
Austria	-0.28	***	60.66	***	4.5E+05	***	249.75	***	127.05	***	72.58	***	0.29	***
Belgium	0.02		127.85	***	2.0E+06	***	508.94	***	237.99	***	120.84	***	0.18	***
Denmark	1.63	***	27.89	***	96409	***	87.27	***	41.66	***	24.36	***	0.21	***
Finland	1.66	***	42.55	***	2.2E+05	***	13.79	***	7.98	***	4.43	***	0.05	***
France	0.59	***	68.15	***	5.7E+05	***	276.95	***	120.56	***	62.86	***	0.20	***
Germany	-0.28	***	72.62	***	6.4E+05	***	252.46	***	128.31	***	73.27	***	0.29	***
Ireland	-0.56	***	113.67	***	1.6E+06	***	218.63	***	103.01	***	63.33	***	0.18	***
Italy	0.23	***	15.55	***	29572	***	127.35	***	60.46	***	35.18	***	0.19	***
Japan	0.44	***	19.96	***	48796	***	71.53	***	31.30	***	21.68	***	0.13	***
Latvia	0.95	***	55.28	***	3.7E+05	***	152.57	***	68.47	***	35.36	***	0.26	***
Lithuania	-0.29	***	95.62	***	1.1E+06	***	56.75	***	26.91	***	13.56	***	0.15	***
Netherlands	3.52	***	69.22	***	5.9E+05	***	10.79	***	4.33	***	5.59	***	0.05	***
Portugal	0.00	***	18.84	***	43385	***	53.57	***	42.23	***	22.61	***	0.17	***
Slovakia	0.66	***	41.44	***	2.1E+05	***	25.14	***	24.62	***	19.31	***	0.11	***
Slovenia	2.59	***	65.14	***	5.2E+05	***	13.23	***	9.82	***	34.88	***	0.11	***
Spain	-0.09	***	50.27	***	3.1E+05	***	195.02	***	78.80	***	39.98	***	0.19	**
Sweden	1.30	***	14.67	***	27127	***	69.49	***	30.82	***	20.72	***	0.16	***
Philippines	0.68	***	18.97	***	44205	***	154.83	***	127.66	***	90.03	***	0.23	***
Turkey	1.12	***	13.91	***	24252	***	69.04	***	86.65	***	46.84	***	0.21	***

Bulgaria	2.37	***	34.43	***	1.5E+05	***	12.71	***	10.36	***	6.72	***	0.08	***
Croatia	-0.50	***	37.86	***	1.8E+05	***	137.90	***	58.87	***	47.62	***	0.26	***
Czech	-0.19	***	36.85	***	1.7E+05	***	62.52	***	46.01	***	29.50	***	0.14	***
Hungary	2.78	***	42.73	***	2.3E+05	***	14.48	***	15.20	***	8.67	***	0.10	***
Greece	-29.18	***	129.45	***	2.1E+08	***	5.E-04		4.E-04		6.E-04		-4.E-04	
Poland	0.22	**	41.33	**	2.1E+05	**	311.98	**	135.64	**	75.78	**	0.21	***
Romania	2.55	***	55.64	***	3.8E+05	***	57.88	***	33.74	***	17.50	***	0.17	***
Ukraine	3.99	***	106.61	***	1.4E+06	***	60.42	***	32.53	***	17.13	***	0.11	***

The Engle's ARCH-LM test with 2, 5 and 10 lag orders informs about the presence of ARCH effects in the series, under the null hypothesis of no autocorrelations in the squared residuals. GPH (Geweke and Porter-Hudak) is the log periodogram test of [61] with d-parameter  $m=1467$ . This test is applied to the squared logarithmic returns (as proxy for unconditional volatility) to detect any long-range dependence under the null assumption of no long-memory behavior in the volatility process. \*, \*\* and \*\*\* denote significance at respectively 10%, 5% and 1% statistical levels.

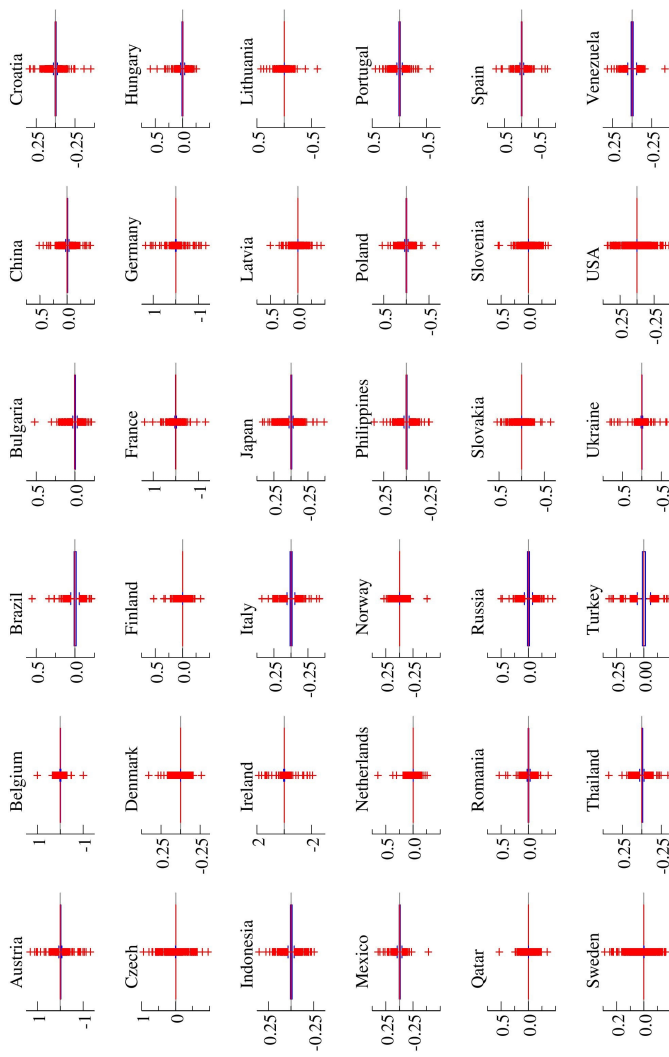


FIGURE 2: Box plots for daily CDS spreads

#### 4.2. Empirical findings

As the first step of our econometric framework is to estimate the conditional volatility, we present in Table C.8 (Appendix Annexe C) the results of the AR(1)-FIAPARCH(1,d,1) estimation for each country. The autoregressive term in the mean equation is almost always significantly positive, which indicates the instantaneous incorporation of past information into current CDS spreads. All CDS spreads (Other than Norway, China and Thailand) exhibit statistically significant fractional differencing parameters ( $d$ ), which implies that the persistence of a shock on the conditional volatility of CDS spreads follows a hyperbolic rate of decay and supports thus the use of fractional integrated model. The GARCH parameters ( $\phi$  and  $\beta$ ) are positive and mainly significant, respecting the model condition of non-negativity. The leverage effect parameter ( $\gamma$ ) is significant, as well, in most cases, which means that losses on CDS operations have a bigger impact on future volatility than do gains. These coefficient estimators confirm, thus, once again, the appropriate use of the AR(1)-FIAPARCH(1,d,1).

The behavioral analysis of the generated time series is conducted through the [62] test. In this paper, the structural breaks test accounts for only two regimes : a 1<sup>st</sup> stable regime corresponds to a low conditional volatility and a 2<sup>nd</sup> risky regime with a high conditional volatility. Results, presented in Table D.9 (Appendix Annexe D), show a strong evidence of regime shifts pattern in all volatility series with a rejection at 5% significance level of the null hypothesis of a zero threshold transition. Therefore, the CDS volatility series of the 38 studied countries are characterized by significant nonlinearities over time, justifying the use of a regime-switching model.

As already mentioned, the optimal number of lags in the threshold variable specification is chosen based on the sum of squared residuals criteria (See Table 5). It is clearly found that the optimal number of lag specifications is different from one country to another. The threshold variable is set using the Bai-Perron breakpoint test [62] with a maximum break of 1 and a trimming

percentage<sup>1</sup> equal to 15.

Results of the self-excited TAR model with exogenous variables, reported in Table 6 and Table E.10 (Appendix Annexe E), reveal some interesting findings. The threshold parameter ( $\hat{\chi}$ ) is positive for all the studied countries. The highest threshold value is observed in France (0.0168), meaning that this CDS market needs greater volatility increase than the other markets to get excited. Yet, Belgium ( $\hat{\chi} = 0.0001$ ), Netherlands ( $\hat{\chi} = 0.0002$ ), Greece ( $\hat{\chi} = 0.0003$ ) and Romania ( $\hat{\chi} = 0.0002$ ) record the lowest threshold values, making them easily excitable with a higher likelihood of switching to the 2<sup>nd</sup> regime.

TABLE 5: Selection of the threshold variable specification

<b>Sum of Squared Residuals (SSR)</b>						
	$VOL_{t-1}$	$VOL_{t-2}$	$VOL_{t-3}$	$VOL_{t-4}$	$VOL_{t-5}$	$VOL_{t-6}$
<b><i>Panel A : Oil-producing countries</i></b>						
Norway	0.0030	0.0031	0.0031	0.0031	0.0031	0.0031
UK	0.0064	0.0065	0.0065	0.0065	0.0066	0.0064
USA	0.1096	0.1126	0.1126	0.1162	0.1151	0.1168
Brazil	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
China	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Mexico	0.0031	0.0031	0.0031	0.0031	0.0031	0.0032
Qatar	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009
Thailand	0.0026	0.0025	0.0026	0.0026	0.0026	0.0026
Indonesia	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Russia	0.0127	0.0128	0.0129	0.0129	0.0127	0.0128
Venezuela	0.0082	0.0083	0.0083	0.0083	0.0084	0.0085
<b><i>Panel B : Other worldwide countries</i></b>						
Austria	0.0076	0.0074	0.0072	0.0074	0.0072	0.0074
Belgium	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Denmark	0.0049	0.0049	0.0049	0.0050	0.0050	0.0050
Finland	0.0126	0.0122	0.0126	0.0126	0.0126	0.0126
France	0.5935	0.5733	0.5873	0.5920	0.5864	0.5849
Germany	1.7902	1.6109	1.6897	1.8114	1.7599	1.7756

1. The minimum length of each sub-sample is equal to 15% of the total observations number.



Ireland	2.1551	1.9232	2.0980	2.0811	2.1505	2.1566
Italy	0.0257	0.0247	0.0258	0.0251	0.0259	0.0257
Japan	0.0086	0.0085	0.0086	0.0086	0.0087	0.0087
Latvia	0.0752	0.0755	0.0749	0.0748	0.0758	0.0752
Lithuania	0.0432	0.0431	0.0434	0.0434	0.0434	0.0435
Netherlands	0.0042	0.0042	0.0043	0.0038	0.0039	0.0041
Portugal	0.1495	0.1468	0.1472	0.1479	0.1462	0.1484
Slovakia	0.0882	0.0891	0.0890	0.0902	0.0904	0.0900
Slovenia	0.0204	0.0204	0.0207	0.0207	0.0209	0.0209
Spain	0.0679	0.0612	0.0671	0.0674	0.0675	0.0655
Sweden	0.0019	0.0019	0.0020	0.0019	0.0020	0.0020
Philippines	0.0661	0.0675	0.0682	0.0690	0.0701	0.0698
Turkey	0.0021	0.0020	0.0021	0.0020	0.0021	0.0022
Bulgaria	0.1210	0.1215	0.1197	0.1209	0.1211	0.1214
Croatia	0.0160	0.0156	0.0161	0.0163	0.0163	0.0161
Czech	0.0139	0.0139	0.0139	0.0140	0.0140	0.0142
Hungary	0.0829	0.0818	0.0817	0.0820	0.0827	0.0825
Greece	0.0049	0.0028	0.0028	0.0047	0.0049	0.0049
Poland	0.0258	0.0256	0.0260	0.0259	0.0258	0.0258
Romania	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Ukraine	0.0346	0.0339	0.0339	0.0339	0.0339	0.0340

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This table reports the Sum of Squared Residuals (SSR) for each model with lag orders from 1 to 6. The chosen model is the one that minimizes the SSR.

As expected, the coefficient estimates of the regressors  $(\omega, \theta_i, \Phi_j)$  vary from one regime to another. Some dissimilarities in the explanatory power of the exogenous variables are observed between regimes and across countries. Even though its past value coefficient is always highly positive and significant regardless the regime, CDS volatility seems to be, for the most, more sensitive to previous shocks during the stable state compared to the risky state.

Overall, it seems that there is relevant heterogeneity in the relative contribution of the control variables in the sovereign default risk : No common determinants are observed for the studied countries and reaction degree of CDS volatility to economic and financial factors seems to vary strongly from one country to another and from one regime to another. Further, the role played by

the macroeconomic and financial factors as key determinants of the sovereign creditworthiness is particularly significant during the high-volatility regime. During the first regime, the stock market return, the Thomson Reuters global stock index and the VIX index are found to be the most linked control variables to sovereign credit risk – as captured by the CDS volatility. Yet, during the high-volatility regime, only the common factors represented by the Thomson Reuters global stock index and the VIX index turn out to be the key drivers of the country’s creditworthiness in most countries.

First, regarding the local financial market variable, a shock in the stock market return affects the CDS volatility in 34% of the studied countries during the tranquil period and in 58% during the turmoil period. The reasonable pattern is that a positive shock in the stock market return leads to a decrease of the CDS volatility. This relationship is verified for the majority of the studied countries, whether during the first or the second regime. On the contrary, among the oil-producing countries, the Brazil and Thailand markets do not seem to respect the pattern sign, for which the relationship between the stock market return and the CDS volatility is rather positive whatever the period is. The same opposite pattern is observed for eight oil-consuming countries (Finland, Japan, Slovakia, Sweden, the Philippines, Bulgaria, Hungary and Ukraine). This unexpected relationship observed in some studied countries (26%) can be explained by a misperception of the microstructure signals by the market participants.

Second, on a theoretical basis, the credit risk level is supposed to be positively related to sovereign bond yields. The sense of this relationship holds more during the tranquil period (77% of the studied countries) than during the volatile period (53%). An increase in the bond yield should be reflected in the overall credit conditions with a rise in the CDS volatility and thus in the country’s default risk. While this hypothesis seems to hold for most countries during the first regime, the opposite pattern is observed in a non-negligible number of countries during the second regime (e.g. The USA, Venezuela, Croatia. . .), probably due to liquidity problems, illogical choices or the confusing current environment encountered by investors.

Third, the state of the government's finances, as captured by the GDP, the amount of the total debts and the amount of the external debts, play an important role in determining the CDS volatility of most cases, particularly during the second regime with statistically significant coefficients recorded in repetitively 63%, 63% and 58% of the countries under study. Based on the theory and the logical reasoning, the country's default risk should increase when the public finances deteriorate, i.e. when the GDP declines and/or the public debt and the external debt widen, and vice versa. The estimated coefficients confirm the expected relationships for several countries : a shock in the GDP leads to a decrease in the creditworthiness of 45% of the countries during the first regime and 50% of the countries during the second regime. Public debt is positively linked to the sovereign credit risk for most considered countries, with 56% and 63% of positive effects during respectively the tranquil and the high-volatility regime. For the external debt, a positive impact is recorded in 53% during the first regime and 40% of the studied countries during the second regime.

Fourth, while the relation between the inflation and the default risk still mitigated in the existing literature, our results point to that for most countries (66% during the tranquil period and 58% during the volatile period) high rate of inflation is perceived as revealing of some structural issues in the public finances. Investors apprehend the inflationary money policy as a sign of budgetary instability and government's inability to pay its debt. In the remaining countries, where a positive relationship is observed between the inflation and the country's creditworthiness, the inflationary trend is rather perceived as an incentive for the economic expansion.

Fifth, a small number of robust relationships is observed between the consumer confidence index and the sovereign default risk (Significant correlation is observed in only 13% of the studied countries during the first regime). This suggests that market participants are not willing to properly consider the consumer's attitudes toward future economic health as a leading indicator of the GDP growth and thus the country's credit worthiness. Nevertheless, the expected patten appears to hold for the countries' majority (53% and 67% negative

relationships are recorded during the tranquil period and the turmoil period). This may reflect the fact that if consumers doubt about the future, they will less purchase and slow thus the economic growth, which implies that the country's existing debt burden will become less easy to handle over time, and vice versa.

Sixth, regarding the common-factors, the Thomson Reuters index – used as a proxy for the worldwide stock market – is statistically significant in 21% of the cases during the low-volatility regime and in 71% of the cases during the high-volatility regime. The lack of significant impacts of the global stock returns in the first period is compensated by the subsequent significant effects in the second period, which reveals that a widening in the global financial market returns is interpreted as an economic development, making the country less likely to default particularly during the high-volatility regime.

Seventh, unsurprisingly and in accordance with the existent literature, the role played by the VIX as a key driver of the CDS volatility is confirmed in almost all the countries (Except for the USA, Brazil and Greece), making the international stock market uncertainty the most significant control variable, whether during the first or the second regime. As expected, a shock in the VIX positively impacts the CDS volatility of all the countries under study, except for Ireland. Used as a measure of the international idiosyncratic risk, the higher the VIX is, the higher the CDS volatility is, which drives to larger country's default probability.

Since the purpose of this paper is to study the impact of oil price and uncertainty on CDS volatility, we are more interested in the WTI and OXV coefficients. During the stable period (1<sup>st</sup> regime), the role played by oil price and oil uncertainty in determining the level of credit risk is, to say the least, trivial with a significant impact only detected in respectively one (Bulgaria) and 7 countries, out of the 38 studied countries. None of these impacted countries belong to the oil-producing category. The explanatory power of oil price seems to be more important during the 2<sup>nd</sup> regime. Oil price significantly impacts, henceforth, the CDS volatility of 25 countries, representing 66% of our studied sample. More particularly, CDS volatility of oil-producing countries are more sensitive to oil

price fluctuations, with significant coefficients in 91% of the sub-sample. Similarly, CDS markets become more sensitive to oil uncertainty, although in a lesser extent, with only 18 countries involved. Thus, movements in the international oil market have greater influence on credit volatility when the CDS markets are excited.

Focusing on oil-producing countries during the 2<sup>nd</sup> regime, oil price has a negative impact in most cases (A positive relationship is only observed in the USA, Brazil and Thailand), although with varied magnitudes. With a threshold value equal to 0.0018, Thailand is the most sensitive CDS market to oil price fluctuations, even though the expected sign is not respected. A 1% increase in oil price leads to an increase in CDS volatility by 82.72%, which is not explained by the reasoning previously supposed. This divergent behavior might be explained by the fact that, even though the oil production in Thailand is increasing during recent years, it still does not cover its consumption needs. To get closer from its needs satisfaction, Thailand has to go through with importations, which weaken its public finances and thus its ability to repay debts. Credit risk sensitivity to oil price shocks can, as well, be explained in the USA and Brazil, as a result of the large quantity of necessary imports to help meet demand, despite the fact that these countries are respectively ranked as the 3<sup>rd</sup> and the 10<sup>th</sup> in the world oil production countries.

Interestingly, the impact of oil uncertainty – as approximated by the OVX index – on the CDS volatility during the risky regime, is mostly negative except that in Thailand, Indonesia, Venezuela and Ukraine, where the sign matches the expected relationship. Reasonably, an increase in the oil market volatility should higher the sovereign credit risk, although this is mainly not the revealed relationship by our empirical findings. This may be attributed to spurious relationships caused by irrational behavior of investors following the frequent occurrence of crisis periods in both CDS and oil markets.

TABLE 6: Estimation results of the SETAR(1) for oil-producing countries

T. variable T. value	Norway				UK				USA				Brazil				China			
	$VOL_{t-1}$ 0.0014		$VOL_{t-6}$ 0.0010		$VOL_{t-1}$ 0.0090		$VOL_{t-2}$ 0.0013		$VOL_{t-1}$ 0.0012		$VOL_{t-2}$ 0.0013		$VOL_{t-1}$ 0.0012		$VOL_{t-4}$ 0.0012					
	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2				
Obs.	2492	439	2451	469	2492	443	2492	442	2492	442	2393	539	2393	539	2393	539				
C	-0.0002 (0.0001)	0.0017 (0.0002)	0.0006 (0.0004)	-0.0002 (0.0015)	-0.0017 (0.0020)	0.0396 (0.0056)	0.0396 (0.0056)	-0.0001 (0.0001)	-0.0009 (0.0002)	-0.0003 (0.0001)	-0.0003 (0.0001)	** (0.0003)	-0.0003 (0.0001)	** (0.0003)	-0.0003 (0.0001)	** (0.0003)				
$Vol_{t-1}$	1.0932 (0.0633)	0.0656 (0.0212)	0.4038 (0.0210)	0.6995 (0.0214)	1.1258 (0.0582)	0.1748 (0.0225)	0.1748 (0.0225)	0.9485 (0.0178)	0.9022 (0.0085)	0.9485 (0.0178)	0.9485 (0.0178)	*** (0.0050)	0.9485 (0.0178)	*** (0.0050)	1.1121 (0.0178)	*** (0.0050)				
SMR	0.0022 (0.0014)	-0.0046 (0.0027)	-0.0032 (0.0030)	0.0169 (0.0051)	-0.0059 (0.0108)	-0.0029 (0.0269)	-0.0029 (0.0269)	0.0020 (0.0005)	0.0050 (0.0008)	0.0020 (0.0005)	0.0020 (0.0005)	*** (0.0006)	0.0020 (0.0005)	*** (0.0006)	-0.0007 (0.0004)	-0.0007 (0.0004)				
RYB	0.0002 (0.0003)	-0.0002 (0.0004)	0.0000 (0.0002)	0.0018 (0.0007)	-0.0001 (0.0012)	-0.0051 (0.0026)	-0.0051 (0.0026)	0.0000 (0.0001)	-0.0004 (0.0003)	0.0000 (0.0003)	0.0000 (0.0003)	** (0.0004)	0.0000 (0.0003)	** (0.0004)	0.0000 (0.0003)	0.0000 (0.0003)				
RGDP	-0.0442 (0.0706)	0.2754 (0.1618)	-0.1517 (0.0541)	-0.0450 (0.0988)	1.8165 (3.2376)	12.0490 (10.5445)	12.0490 (10.5445)	2.8085 (97.6948)	-276.3434 (269.8486)	2.8085 (97.6948)	2.8085 (97.6948)	0.0164 (0.0378)	0.0164 (0.0378)	-0.0337 (0.1701)	0.0164 (0.0378)	-0.0337 (0.1701)				
RDEBT	0.0086 (0.0084)	0.1067 (0.0397)	-0.4487 (0.1419)	0.0831 (0.5204)	0.1640 (0.3323)	1.3727 (0.8208)	1.3727 (0.8208)	-2.8121 (97.6948)	276.1857 (269.8482)	-2.8121 (97.6948)	276.1857 (269.8482)	0.0390 (0.0365)	0.0390 (0.0365)	0.0057 (0.0868)	0.0390 (0.0365)	0.0057 (0.0868)				
REDEBT	0.0086 (0.0266)	-0.0184 (0.0771)	-0.0056 (0.0456)	-0.0595 (0.0899)	-1.4768 (1.3564)	-23.7262 (4.0890)	-23.7262 (4.0890)	-0.0064 (0.0135)	-0.1153 (0.0312)	-0.0064 (0.0135)	-0.1153 (0.0312)	-0.0208 (0.0130)	-0.0208 (0.0130)	-0.0224 (0.0482)	-0.0208 (0.0130)	-0.0224 (0.0482)				
INF	0.0086 (0.0837)	-0.4853 (0.1885)	0.1058 (0.2144)	0.2641 (0.5193)	-0.0731 (0.8853)	-0.5608 (2.6548)	-0.5608 (2.6548)	0.0216 (0.0613)	0.2196 (0.1760)	0.0216 (0.0613)	0.2196 (0.1760)	0.0035 (0.0265)	0.0035 (0.0265)	0.2375 (0.0526)	0.0035 (0.0265)	0.2375 (0.0526)				
RCCI	0.0001 (0.0002)	-0.0057 (0.0026)	-3.79E-05 (0.0002)	0.0042 (0.0005)	0.0216 (0.0242)	-0.3348 (0.0613)	-0.3348 (0.0613)	0.0004 (0.0043)	-0.0708 (0.0104)	0.0004 (0.0043)	-0.0708 (0.0104)	-0.0024 (0.0064)	-0.0024 (0.0064)	0.0195 (0.0199)	-0.0024 (0.0064)	0.0195 (0.0199)				
RTRGI	3.33E-06 (2.61E-06)	0.0000 (0.0000)	-5.20E-06 (1.98E-06)	2.33E-06 (8.93E-06)	9.64E-06 (8.51E-06)	-0.0002 (2.82E-05)	-0.0002 (2.82E-05)	7.70E-07 (4.65E-07)	4.55E-06 (1.27E-06)	7.70E-07 (4.65E-07)	4.55E-06 (1.27E-06)	** (5.94E-07)	4.55E-06 (1.27E-06)	** (5.94E-07)	1.18E-06 (5.94E-07)	9.40E-07 (1.18E-06)				
VIX	7.28E-06 (3.80E-06)	0.0000 (0.0000)	3.63E-05 (8.38E-06)	3.64E-05 (1.52E-05)	3.65E-05 (3.06E-05)	4.03E-05 (0.0001)	4.03E-05 (0.0001)	4.49E-06 (1.77E-06)	2.75E-05 (3.01E-06)	4.49E-06 (1.77E-06)	2.75E-05 (3.01E-06)	*** (1.86E-06)	2.75E-05 (3.01E-06)	*** (1.86E-06)	8.96E-07 (2.78E-06)	7.59E-06 (2.78E-06)				
RWTI	-0.0012 (0.0011)	* (0.0021)	-0.0005 (0.0015)	-0.0067 (0.0032)	0.0060 (0.0060)	0.0356 (0.0165)	0.0356 (0.0165)	0.0005 (0.0003)	0.0038 (0.0006)	0.0005 (0.0003)	0.0038 (0.0006)	** (0.0003)	0.0005 (0.0003)	** (0.0003)	0.0001 (0.0003)	-0.0017 (0.0003)				
OVX	- (0.0011)	- (0.0021)	-3.20E-06 (3.75E-06)	-1.32E-05 (8.19E-06)	6.06E-06 (1.51E-05)	-0.0001 (3.89E-05)	-0.0001 (3.89E-05)	-8.43E-07 (8.89E-07)	-3.77E-06 (1.98E-06)	-8.43E-07 (8.89E-07)	-3.77E-06 (1.98E-06)	* (8.00E-07)	-3.77E-06 (1.98E-06)	* (8.00E-07)	4.76E-07 (1.98E-06)	-9.94E-07 (1.98E-06)				

TABLE 6: Estimation results of the SETAR(1) for oil-producing countries (*Continued*)

T. variable	Mexico						Qatar						Thailand						Indonesia						Russia					
	VOL <sub>t-2</sub>			VOL <sub>t-5</sub>			VOL <sub>t-5</sub>			VOL <sub>t-2</sub>			VOL <sub>t-2</sub>			VOL <sub>t-2</sub>			VOL <sub>t-2</sub>			VOL <sub>t-5</sub>			VOL <sub>t-5</sub>					
	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2				
Obs.	2481	453	2492	439	2494	440	441	2493	441	2493	441	441	2493	441	2493	441	2493	441	2493	441	2493	441	2493	441	2493	441	2493			
C	-0.0001 (0.0003)	-0.0023 (0.0009)	-0.0002 (0.0002)	-0.0007 (0.0004)	0.0000 (0.0002)	-0.0048 (0.0008)	-0.0008 (0.0003)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	
VOL <sub>t-1</sub>	0.9639 (0.0384)	0.9287 (0.0067)	0.7574 (0.0205)	0.8549 (0.0114)	1.0175 (0.0334)	0.8092 (0.0113)	0.9611 (0.0071)	0.9790 (0.0227)	0.8092 (0.0113)	0.9790 (0.0227)	0.8092 (0.0113)	0.9611 (0.0071)	0.9790 (0.0227)	0.8092 (0.0113)	0.9790 (0.0227)	0.8092 (0.0113)	0.9611 (0.0071)	0.9790 (0.0227)	0.8092 (0.0113)	0.9611 (0.0071)	0.9790 (0.0227)	0.8092 (0.0113)	0.9611 (0.0071)	0.9790 (0.0227)	0.8092 (0.0113)	0.9611 (0.0071)	0.9790 (0.0227)	0.8092 (0.0113)	0.9611 (0.0071)	0.9790 (0.0227)
SMR	-0.0025 (0.0020)	-0.0131 (0.0032)	-0.0013 (0.0009)	-	0.0010 (0.0017)	0.0196 (0.0026)	0.0017 (0.0009)	0.0001 (0.0006)	0.0010 (0.0017)	0.0001 (0.0006)	0.0010 (0.0017)	0.0001 (0.0006)	0.0010 (0.0017)	0.0001 (0.0006)	0.0010 (0.0017)	0.0001 (0.0006)	0.0010 (0.0017)	0.0001 (0.0006)	0.0010 (0.0017)	0.0001 (0.0006)	0.0010 (0.0017)	0.0001 (0.0006)	0.0010 (0.0017)	0.0001 (0.0006)	0.0010 (0.0017)	0.0001 (0.0006)	0.0010 (0.0017)	0.0001 (0.0006)	0.0010 (0.0017)	
BY	0.0009 (0.0018)	0.0152 (0.0033)	-	-0.0043 (0.0013)	-0.0009 (0.0012)	0.0057 (0.0018)	0.0022 (0.0007)	0.0002 (0.0004)	0.0009 (0.0012)	0.0002 (0.0004)	0.0009 (0.0012)	0.0002 (0.0004)	0.0009 (0.0012)	0.0002 (0.0004)	0.0009 (0.0012)	0.0002 (0.0004)	0.0009 (0.0012)	0.0002 (0.0004)	0.0009 (0.0012)	0.0002 (0.0004)	0.0009 (0.0012)	0.0002 (0.0004)	0.0009 (0.0012)	0.0002 (0.0004)	0.0009 (0.0012)	0.0002 (0.0004)	0.0009 (0.0012)	0.0002 (0.0004)	0.0009 (0.0012)	
GDP	0.0179 (0.0532)	0.0922 (0.1236)	0.0043 (0.0129)	-0.1005 (0.0302)	0.0164 (0.0334)	0.3815 (0.1051)	0.1466 (0.0462)	-0.0035 (0.0150)	0.0164 (0.0334)	0.3815 (0.1051)	0.1466 (0.0462)	-0.0035 (0.0150)	0.0164 (0.0334)	0.3815 (0.1051)	0.1466 (0.0462)	-0.0035 (0.0150)	0.0164 (0.0334)	0.3815 (0.1051)	0.1466 (0.0462)	-0.0035 (0.0150)	0.0164 (0.0334)	0.3815 (0.1051)	0.1466 (0.0462)	-0.0035 (0.0150)	0.0164 (0.0334)	0.3815 (0.1051)	0.1466 (0.0462)	-0.0035 (0.0150)	0.0164 (0.0334)	0.3815 (0.1051)
DEBT	-0.0043 (0.0290)	-0.4194 (0.0540)	0.0154 (0.0251)	0.0853 (0.0763)	-0.0058 (0.0304)	-0.0561 (0.0662)	0.2614 (0.0552)	0.0065 (0.0175)	-0.0058 (0.0304)	0.0853 (0.0763)	-0.0561 (0.0662)	0.2614 (0.0552)	0.0065 (0.0175)	-0.0058 (0.0304)	0.0853 (0.0763)	-0.0561 (0.0662)	0.2614 (0.0552)	0.0065 (0.0175)	-0.0058 (0.0304)	0.0853 (0.0763)	-0.0561 (0.0662)	0.2614 (0.0552)	0.0065 (0.0175)	-0.0058 (0.0304)	0.0853 (0.0763)	-0.0561 (0.0662)	0.2614 (0.0552)	0.0065 (0.0175)	-0.0058 (0.0304)	
EDEBT	-0.0106 (0.0393)	-0.3085 (0.0883)	-0.0177 (0.0286)	-0.0941 (0.0946)	-0.0372 (0.0348)	0.3405 (0.0977)	0.0640 (0.0553)	0.0012 (0.0135)	-0.0372 (0.0348)	0.3405 (0.0977)	0.0640 (0.0553)	0.0012 (0.0135)	-0.0372 (0.0348)	0.3405 (0.0977)	0.0640 (0.0553)	0.0012 (0.0135)	-0.0372 (0.0348)	0.3405 (0.0977)	0.0640 (0.0553)	0.0012 (0.0135)	-0.0372 (0.0348)	0.3405 (0.0977)	0.0640 (0.0553)	0.0012 (0.0135)	-0.0372 (0.0348)	0.3405 (0.0977)	0.0640 (0.0553)	0.0012 (0.0135)	-0.0372 (0.0348)	
INF	0.0136 (0.1248)	-0.0174 (0.3380)	-0.0692 (0.0773)	-0.1633 (0.2694)	0.0164 (0.0822)	-0.9505 (0.1608)	0.1050 (0.0614)	0.0042 (0.0295)	0.0164 (0.0822)	-0.9505 (0.1608)	0.1050 (0.0614)	0.0042 (0.0295)	0.0164 (0.0822)	-0.9505 (0.1608)	0.1050 (0.0614)	0.0042 (0.0295)	0.0164 (0.0822)	-0.9505 (0.1608)	0.1050 (0.0614)	0.0042 (0.0295)	0.0164 (0.0822)	-0.9505 (0.1608)	0.1050 (0.0614)	0.0042 (0.0295)	0.0164 (0.0822)	-0.9505 (0.1608)	0.1050 (0.0614)	0.0042 (0.0295)	0.0164 (0.0822)	
CCI	-0.0027 (0.0124)	-0.1611 (0.0405)	-	-	-0.0065 (0.0204)	-0.2137 (0.0501)	0.0295 (0.0129)	-0.0013 (0.0042)	-0.0065 (0.0204)	-0.2137 (0.0501)	0.0295 (0.0129)	-0.0013 (0.0042)	-0.0065 (0.0204)	-0.2137 (0.0501)	0.0295 (0.0129)	-0.0013 (0.0042)	-0.0065 (0.0204)	-0.2137 (0.0501)	0.0295 (0.0129)	-0.0013 (0.0042)	-0.0065 (0.0204)	-0.2137 (0.0501)	0.0295 (0.0129)	-0.0013 (0.0042)	-0.0065 (0.0204)	-0.2137 (0.0501)	0.0295 (0.0129)	-0.0013 (0.0042)	-0.0065 (0.0204)	
TRGI	6.71E-08 (0.0000)	1.40E-05 (4.35E-06)	1.13E-06 (8.54E-07)	7.65E-06 (1.92E-06)	-2.77E-07 (1.28E-06)	2.04E-05 (4.20E-06)	2.54E-06 (1.62E-06)	4.33E-09 (4.31E-07)	-2.77E-07 (1.28E-06)	7.65E-06 (1.92E-06)	-2.77E-07 (1.28E-06)	2.04E-05 (4.20E-06)	2.54E-06 (1.62E-06)	4.33E-09 (4.31E-07)	-2.77E-07 (1.28E-06)	7.65E-06 (1.92E-06)	-2.77E-07 (1.28E-06)	2.04E-05 (4.20E-06)	2.54E-06 (1.62E-06)	4.33E-09 (4.31E-07)	-2.77E-07 (1.28E-06)	7.65E-06 (1.92E-06)	-2.77E-07 (1.28E-06)	2.04E-05 (4.20E-06)	2.54E-06 (1.62E-06)	4.33E-09 (4.31E-07)	-2.77E-07 (1.28E-06)	7.65E-06 (1.92E-06)	-2.77E-07 (1.28E-06)	
VIX	4.33E-06 (5.64E-06)	0.0001 (1.17E-05)	9.06E-06 (3.48E-06)	4.05E-05 (4.93E-06)	7.09E-06 (4.86E-06)	0.8285 (9.58E-06)	9.80E-06 (1.35E-05)	1.75E-06 (1.76E-06)	7.09E-06 (4.86E-06)	4.05E-05 (4.93E-06)	4.82E-05 (6.51E-06)	9.80E-06 (1.35E-05)	1.75E-06 (1.76E-06)	1.75E-06 (1.76E-06)	9.80E-06 (1.35E-05)	3.88E-05 (5.63E-06)	3.88E-05 (5.63E-06)	9.80E-06 (1.35E-05)	1.75E-06 (1.76E-06)	1.75E-06 (1.76E-06)	9.80E-06 (1.35E-05)	3.88E-05 (5.63E-06)	3.88E-05 (5.63E-06)	9.80E-06 (1.35E-05)	1.75E-06 (1.76E-06)	1.75E-06 (1.76E-06)	9.80E-06 (1.35E-05)	3.88E-05 (5.63E-06)	3.88E-05 (5.63E-06)	
WTI	-0.0011 (0.0011)	-0.0128 (0.0018)	-0.0004 (0.0006)	-0.0042 (0.0009)	-0.0001 (0.0010)	0.8272 (0.0015)	0.0001 (0.0006)	0.0001 (0.0006)	-0.0001 (0.0010)	-0.0042 (0.0009)	0.8272 (0.0015)	0.0001 (0.0006)	0.0001 (0.0006)	-0.0001 (0.0010)	-0.0042 (0.0009)	0.8272 (0.0015)	0.0001 (0.0006)	0.0001 (0.0006)	-0.0001 (0.0010)	-0.0042 (0.0009)	0.8272 (0.0015)	0.0001 (0.0006)	0.0001 (0.0006)	-0.0001 (0.0010)	-0.0042 (0.0009)	0.8272 (0.0015)	0.0001 (0.0006)	0.0001 (0.0006)	-0.0001 (0.0010)	
OVX	4.60E-08 (2.82E-06)	-2.89E-05 (5.39E-06)	-1.22E-06 (1.38E-06)	-2.51E-05 (3.68E-06)	-1.02E-06 (2.27E-06)	0.0006 (6.51E-06)	6.41E-06 (2.48E-06)	-1.79E-07 (8.18E-07)	-1.02E-06 (2.27E-06)	-2.51E-05 (3.68E-06)	-1.79E-07 (8.18E-07)	6.41E-06 (2.48E-06)	6.41E-06 (2.48E-06)	-1.79E-07 (8.18E-07)	-1.02E-06 (2.27E-06)	0.0006 (6.51E-06)	6.41E-06 (2.48E-06)	6.41E-06 (2.48E-06)	-1.79E-07 (8.18E-07)	-1.02E-06 (2.27E-06)	-2.51E-05 (3.68E-06)	-1.79E-07 (8.18E-07)	6.41E-06 (2.48E-06)	6.41E-06 (2.48E-06)	-1.79E-07 (8.18E-07)	-1.02E-06 (2.27E-06)	-2.51E-05 (3.68E-06)	-1.79E-07 (8.18E-07)	6.41E-06 (2.48E-06)	

TABLE 6: Estimation results of the SETAR(1) for oil-producing countries (*Continued*)

		Venezuela	
T. variable	$VOL_{t-1}$	Regime 1	Regime 2
T. value	0.0018		
Obs.	2433		469
C	3.31E-05 (0.0014)	-0.0170 (0.0057)	*** ***
$VOL_{t-1}$	0.8598 (0.0967)	*** (0.0181)	*** ***
SMR	0.0008 (0.0021)	-0.0039 (0.0033)	
BY	-	-	-
GDP	0.0667 (0.0651)	-0.3936 (0.2506)	
DEBT	-0.0286 (0.0289)	-0.1355 (0.0967)	
EDEBT	-0.1375 (0.1383)	0.0763 (0.6043)	
INF	0.0501 (0.0430)	-0.0060 (0.0639)	
CCI	-	-	-
TRGI	2.29E-06 (2.71E-06)	4.49E-05 (8.80E-06)	*** ***
VIX	8.36E-06 (6.57E-06)	0.0002 (1.47E-05)	*** ***
WTI	-0.0013 (0.0017)	-0.0233 (0.0028)	*** ***
OVX	-4.68E-10 (1.86E-09)	1.20E-08 (7.67E-09)	

T. variable and T. value refer to the threshold chosen variable and the threshold value used. Regime 1(2) corresponds to the period where Threshold variable chosen < Threshold value (Threshold variable chosen  $\geq$  Threshold value). \*, \*\* and \*\*\* significance at respectively 10%, 5% and 1% statistical levels.



## 5. Discussion

The study of the credit risk determinants, with a particular emphasis on the impact of oil market conditions seems to be interesting all the more during the current unstable context of energy and climate policies and the recent episodes of pumping up and down in oil price. An increase in oil price is expected to raise the financial health and thus the creditworthiness uncertainty of oil-related countries, although this reasoning perspective doesn't always hold for all studied countries and during all periods.

The increase in oil price leads, in the majority of the studied countries, to a worsening of the government's financial health and thus to increase its credit risk. At the opposite, a decline in the oil market conditions potentially raises the country's incomes, which leads to lower the sovereign debt burden and the financing costs, in turn. If the country spends less money serving the debt, then it will hold over revenues, implying greater indebtedness ability. Interestingly, our findings show that this relationship does not hold for some of the studied countries, in which the CDS volatility divergently behaves to oil shocks (the USA, Brazil, Thailand, Sweden, Bulgaria and Hungary). These countries are characterized by a diversified economy : Even though some of them are ranked as the world top oil-producing countries, they still rely on importations to cover their oil consumption needs. The increase in oil price leads, indubitably, to higher imports charges and less government's revenue, which weakens the country's public finances. This leads, in turn, to deteriorate the stability of sovereign solvency, which increases the credit risk and tightens the financing conditions (as reflected in CDS volatility). In some other countries the relationship between oil and CDS markets are statistically insignificant (Finland, Ireland, Spain, Philippines, Greece, Romania and Ukraine). This can be explained by the fact that these countries are not big producers of oil but are self-reliant with their oil needs. In these countries the government reimbursement ability is not or very little sensitive to oil price fluctuations.

Reactions of CDS volatility to higher uncertainty in the oil market is, sur-

prisingly, negative for most cases. This spurious relationship can be explained by irrational trading strategies during the recent crisis periods in both CDS and oil markets. However, these empirical results remain inconclusive.

Our findings are of prominent importance for both regulators and investors. From a policymaker point of view, understanding the source of sovereign risk is a crucial step to properly adjust the policy-decision during extreme situations. Our first result is that the sovereign CDS market, as an indicator of the credit risk, is subject to regime shifts, and its determinants are depending on whether it is highly volatile (and thus risky) or low volatile (and thus safe). This suggests that the key drivers of the credit risk should be continually investigated in order to keep the economic measures and policies viable. Yet, the impact of oil market conditions on CDS volatility was, initially, trivial, but becomes a significant factor in the sovereign risk appreciation, during the risky period. This finding proposes to take into account current, historical and forecasted oil price while elaborating crisis exit solutions.

Understanding the impact of changes in the energy market conditions on the sovereign credit risk is also of critical usefulness for financial markets participants because CDS contracts are widely traded in a speculative purpose. In fact, investors use this credit derivative not only to transfer credit risk but also to generate extra returns by forecasting its prices based on the market psychology. Our results can be helpful for fund managers, so they can make investment profits from simultaneous trading on oil assets and CDS contracts, by basing their strategies on volatility trend of each market. For example, we suggest increasing the oil investment weight in the portfolio if the energy market is bullish and decreasing, at the same time, the CDS investment weight.

## **6. Conclusion**

This paper investigates the impact of oil prices fluctuations on sovereign credit risk, after controlling for local and global economy-wide factors. Using the CDS volatility as a complementary risk measure, our results confirm, firstly,

the nonlinearity pattern of the dynamic evolution of the CDS market volatility. Secondly, some dissimilarities in the explanatory power of the exogenous control variables are observed between regimes and across countries. Thirdly, in most cases, the role played by the oil market is trivial in the determination of credit risk during the stable regime, whilst it becomes significant when the market switches to the risky regime. The majority of the studied countries exhibit a similar behavior, that is the increase in oil price leads to an improvement of the government's creditworthiness, reflected in the CDS volatility decline.

Our paper contributes to the literature in several conclusions : First, investigating the determinants of worldwide CDS volatility is of a prominent issue since understanding the credit risk source may help to better implement crisis exit solutions and to readjust the investment strategies based on the countries' particular features. Second, since oil price decline may lead to the deterioration of the repayment ability of some states, during volatile period, policymakers should settle some rescue packages with respect to the anticipated fluctuations in oil market conditions. And third, market participants should avoid investing simultaneously in the oil market and the sovereign CDS market of some countries during periods of accelerating volatility and instability, because of their close comovement.

Further investigation is needed to explain the unexpected relationship between oil market uncertainty, as approximated by the OVX, and the sovereign CDS volatility. Preliminary findings, revealed in this paper, slightly suggest a miss-appreciation of oil volatility by the CDS market investors, but still not conclusive. Including a variable measuring the political risk of countries in the studied model could provide an early answer to this question.

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## Annexe A. Cubic Spline Interpolation

As mentioned before, to obtain daily data from monthly, quarterly or annual observations, we need to use a mathematical technique that enables to construct a regular continuous curve that passes by all known points. The Spline Interpolation method is one of the most widely used process that allows to create a  $\mathcal{C}^2$  function starting with  $n + 1$  couples  $(x_i, f(x_i))_{i \in \llbracket 0, n \rrbracket}$ . A spline is a special function defined piecewise by polynomials. In our case, we chose to use degree 3 polynomials, which is the lowest degree allowing to build the  $\mathcal{C}^2$  function.

Let's start from the given points of Figure A.3, our goal is to draw the  $\mathcal{C}^2$  function as displayed in Figure A.4.

On each sub-interval  $[x_i, x_{i+1}]$ , we aim to build a polynomial, based on a third-order Taylor polynomial of the sought function written in the neighborhood of  $x_i$ , such as :

$$p_i(x) = f_i + f'_i(x - x_i) + \frac{f''_i}{2!}(x - x_i)^2 + \frac{f'''_i}{3!}(x - x_i)^3, \quad i \in \llbracket 0, n - 1 \rrbracket \quad (\text{A.1})$$

The goal is then to explicit the constants  $(f_i, f'_i, f''_i, f'''_i)_{i \in \llbracket 0, n-1 \rrbracket}$  using the known information i.e. the couples  $(x_i, f(x_i))_{i \in \llbracket 0, n \rrbracket}$ , under certain conditions :

- We want the curve to pass by our points  $(x_i, f(x_i)) \Rightarrow \forall i \in \llbracket 0, n-1 \rrbracket, p_i(x_i) = f(x_i)$  and also at the right endpoint of the interval :  $p_{n-1}(x_n) = f(x_n)$ ,
- The function must be  $\mathcal{C}^0 \Rightarrow \forall i \in \llbracket 0, n-2 \rrbracket, p_i(x_{i+1}) = p_{i+1}(x_{i+1})$ ,
- The function must be  $\mathcal{C}^1 \Rightarrow \forall i \in \llbracket 0, n-2 \rrbracket, p'_i(x_{i+1}) = p'_{i+1}(x_{i+1})$ ,
- The function must be  $\mathcal{C}^2 \Rightarrow \forall i \in \llbracket 0, n-2 \rrbracket, p''_i(x_{i+1}) = p''_{i+1}(x_{i+1})$ .

The constants  $(f'_i, f'''_i)_{i \in \llbracket 0, n-1 \rrbracket}$  are first expressed depending on  $(f''_i)_{i \in \llbracket 0, n \rrbracket}$ , since those are directly written with the known variables. Indeed, the final equations are :

$$f_i = f(x_i), \forall i \in \llbracket 0, n-1 \rrbracket \quad (\text{A.2})$$

$$f'_i = \frac{f(x_{i+1}) - f(x_i)}{h} - h \left[ \frac{f''_i}{3} + \frac{f''_{i+1}}{6} \right], \quad \forall i \in \llbracket 0, n-1 \rrbracket \quad (\text{A.3})$$

$$f'''_i = \frac{f''_{i+1} - f''_i}{h}, \quad \forall i \in \llbracket 0, n-1 \rrbracket \quad (\text{A.4})$$

$$f''_i + 4f''_{i+1} + f''_{i+2} = \frac{6}{h^2} [2f(x_{i+1}) - f(x_{i+2}) - f(x_i)], \quad \forall i \in \llbracket 0, n-2 \rrbracket \quad (\text{A.5})$$

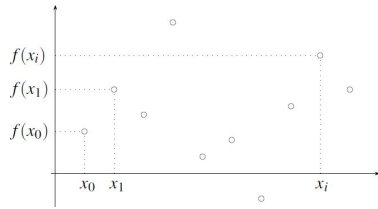


FIGURE A.3: Available data  $(x_i, f(x_i))$

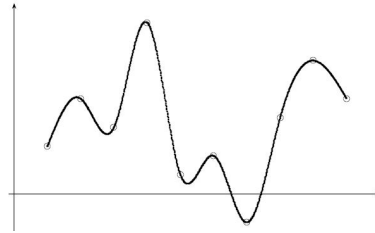


FIGURE A.4: Constructed  $\mathcal{C}^2$  using natural cubic spline interpolation

At this point, an algorithm is enough to find an explicit solution to the  $(f''_i)$  and thus to the entire problem. The great advantage of our hypothesis is

that the main difficulty in the algorithm is the calculation of the inverse of a symmetrical tridiagonal matrix (as shown in Equation A.2), which is quite time effective.

## Annexe B. Unit root test on daily explanatory variables

TABLE B.7: Unit root test for the exogenous variables

Augmented Dickey-Fuller statistics								
Common factors	TRGI	VIX	WTI	OVX				
	-1.53	-3.34 **	-1.82	-3.11 ***				
Country-specific factors	Stock market indexes	Bond yields	GDP	Total debt	Foreign debt	HICP	CCI	
<i>Panel A : Oil-producing countries</i>								
Norway	-2.10	-1.99	-1.05	-1.68	-3.87 *	-0.05	-1.18	
UK	-1.76	-1.92	-1.36	-4.15 *	-2.17	-1.79	-1.47	
USA	0.24	-2.83 *	3.51	-0.55	0.59	-1.25	-1.16	
Brazil	-2.44	-2.93 *	4.39	4.39	-1.67	5.40	-1.28	
China	-2.46	-3.73 *	-4.16 *	6.21	1.01	-0.87	-2.64 *	
Mexico	-1.46	-1.80	0.67	0.84	0.09	0.88	-1.96	
Qatar	-1.91	-	-1.88	-0.94	-0.93	1.04	-	
Thailand	-0.58	-2.06	-0.36	0.28	-1.01	-1.97	-3.14 *	
Indonesia	-0.94	-2.50	0.86	2.54	0.73	0.42	-2.15	
Russia	-1.85	-2.51	-2.02	3.51	-2.50	-5.23 *	-1.67	
Venezuela	4.40	-4.90 *	-3.47 *	-0.93	-5.38 *	3.07	-	
<i>Panel B : Other worldwide countries</i>								
Austria	-1.57	-0.43	-3.34 *	-0.79	-1.19	-0.68	-1.75	
Belgium	-1.23	-0.48	-0.34	1.99	-1.98	-1.26	-2.56	
Denmark	-0.48	-1.23	-1.74	-1.06	-0.01	-2.24	-2.48	
Finland	-0.84	-1.16	-1.49	-0.16	-2.05	-1.78	-2.15	
France	-1.66	-0.58	1.58	-3.90 *	-3.33 *	-1.70	-1.54	
Germany	-0.50	-1.45	-0.38	-2.09	-1.94	-1.44	-1.77	
Ireland	-1.09	-1.47	1.04	-3.64 *	-1.71	-3.32 *	-1.42	
Italy	-1.52	-2.94 *	-2.16	-1.22	-2.95 *	-2.53	-1.57	
Japan	-1.51	-1.56	-0.45	-0.43	-0.85	-1.05	-2.20	
Latvia	-0.57	-1.16	-1.86	-1.85	-4.28 *	-3.91 *	-1.51	
Lithuania	-1.03	-4.02 *	-2.47	-3.42 *	-2.32	-3.00 *	-1.33	

Netherlands	-1.32	-1.21	-0.62	-1.35	-3.14	*	-1.29	-0.81		
Portugal	-0.96	-1.53	-0.45	-0.04	-3.31	*	-1.65	-0.80		
Slovakia	-1.35	-1.02	-2.66	*	-0.05	-0.52	-2.17	-1.75		
Slovenia	-0.78	-3.01	*	-1.85	0.24	-0.64	-2.34	-2.31		
Spain	-1.79	-2.65	*	-4.09	*	0.52	-4.03	*	-2.02	-1.41
Sweden	-2.54	-1.94	-1.47	-1.51	-1.05	-2.04	-2.35			
Philippines	-0.81	-0.81	-1.24	-2.04	-2.93	*	-1.40	-0.86		
Turkey	-1.24	-3.30	*	-0.39	2.49	-1.88	2.68	-2.94	*	
Bulgaria	-1.14	-0.57	-3.59	*	1.08	-4.63	*	-4.71	*	-0.99
Croatia	-1.27	-1.02	-3.71	*	-3.42	*	-0.84	-2.37	-1.26	
Czech	-1.67	-0.48	0.16	-1.62	-0.39	-1.79	-1.31			
Hungary	-1.09	-2.69	*	-3.29	*	-1.39	-2.56	-5.45	*	-1.42
Greece	-0.97	-2.15	-1.20	-1.88	-2.18	-2.17	-1.81			
Poland	-1.77	-0.97	-2.00	-0.53	-2.59	*	-2.69	*	-1.07	
Romania	-0.15	-2.62	*	-2.86	*	0.60	-1.96	-0.21	-0.98	
Ukraine	-1.38	-4.98	*	0.81	1.92	-5.08	*	-4.85	*	-2.37

This table reports the Augmented-Dickey Fuller statistics. GDP, HICP, CCI and TRGI refer to the Gross Domestic Product, the Harmonized Consumer Prices, the Consumer confidence index and Thomson Reuters Global index. \*, \*\* and \*\*\* denote significance at respectively 10%, 5% and 1% statistical levels.

### Annexe C. Univariate FIAPARCH(1,d,1)



TABLE C.8: Estimation results of the AR(1)-FIAPARCH(1,d,1)

	Mean Equation			Variance Equation					Student ( <i>df</i> )	G.E.D ( <i>r</i> )
	Cst. ( <i>m</i> )	AR(1)	AR(1)	d-FIGARCH	ARCH ( $\phi$ )	GARCH ( $\beta$ )	APARCH ( $\gamma$ )	APARCH ( $\delta$ )		
<b>Panel A: Oil-producing countries</b>										
Norway	0.9960 *** (0.0075)	0.4681 *** (0.0114)	0.4681 *** (0.0114)	0.0432 (0.1366)	0.0104 (0.0255)	-0.2359 (0.0734)	1.2339 *** (0.0391)	-	6.1064 *** (0.9118)	-
UK	-5.9E-06 (9.3E-06)	0.9742 *** (0.0128)	0.9742 *** (0.0128)	0.8412 *** (0.0113)	0.2070 *** (0.0370)	0.4596 (0.0662)	0.0078 (0.0307)	0.8948 *** (0.0254)	5.8629 *** (0.8157)	-
USA	2.6E-06 (6.6E-06)	0.3051 *** (0.0194)	0.3051 *** (0.0194)	0.6989 *** (0.0121)	0.3683 *** (0.0626)	0.2248 (0.8002)	-0.4818 *** (0.0327)	1.0242 *** (0.0374)	3.9837 *** (0.2604)	-
Brazil	-0.0001 (0.0001)	0.0946 *** (0.0013)	0.0946 *** (0.0013)	0.9767 *** (0.0519)	0.0355 (0.0431)	0.8860 (0.0201)	-0.7420 ** (0.3748)	1.4484 *** (0.2005)	-	0.6818 *** (0.1159)
China	0.0003 (0.0004)	-0.0126 (0.0337)	-0.0126 (0.0337)	0.1333 (0.2295)	0.8138 *** (0.1588)	-0.7194 (0.3248)	-0.1789 ** (0.0898)	2.2654 *** (0.8115)	-	-
Mexico	-0.0002 (0.0001)	0.5305 *** (0.2549)	0.5305 *** (0.2549)	0.3902 *** (0.0902)	0.0363 (0.0849)	0.3986 (0.1507)	0.0241 (0.5305)	1.9781 *** (0.0950)	-	1.0584 *** (0.1688)
Qatar	2.4E-05 (1.3E-05)	0.0521 * (0.0512)	0.0521 * (0.0512)	0.9881 *** (0.0561)	0.0000 (0.0903)	0.8198 (0.0165)	-0.4823 *** (0.1620)	0.8543 *** (0.0920)	2.9854 *** (0.0740)	-
Thailand	3.2E-05 (4.2E-05)	0.6541 *** (0.0372)	0.6541 *** (0.0372)	0.5138 (0.6185)	0.2091 (0.5873)	0.5123 (0.1101)	0.0718 (0.4927)	1.1961 * (0.6896)	-	0.6983 *** (0.0975)
Indonesia	-0.0004 (0.0025)	1.0000 *** (0.0000)	1.0000 *** (0.0000)	0.9683 *** (0.0147)	0.0499 (0.0433)	0.9086 (0.0022)	-0.1556 *** (0.0166)	0.5404 *** (0.0108)	3.4702 *** (0.0918)	-
Russia	-0.0010 (0.0006)	0.1158 *** (0.0234)	0.1158 *** (0.0234)	0.4613 *** (0.0679)	0.1432 ** (0.0695)	0.3882 (0.0834)	-0.2066 (0.0732)	1.6963 (0.1238)	4.3007 *** (0.3528)	-
Venezuela	0.0000 (1.8E-05)	0.5959 *** (0.0672)	0.5959 *** (0.0672)	0.3994 *** (0.0135)	0.3320 *** (0.1221)	0.3885 (0.0945)	-0.1213 *** (0.6052)	1.6164 *** (0.0971)	3.1431 *** (0.1146)	-
<b>Panel B: Other worldwide countries</b>										
Austria	1.0E-05 (0.0001)	-0.0341 *** (0.0010)	-0.0341 *** (0.0010)	0.9382 *** (0.1901)	0.4147 ** (0.2025)	0.9602 (0.0197)	-0.2099 (0.1429)	0.2635 *** (0.0277)	2.9992 *** (0.1996)	-
Belgium	-4.0E-06 (0.0001)	0.0388 *** (0.0010)	0.0388 *** (0.0010)	0.7369 *** (0.0308)	0.1080 *** (0.0357)	0.7577 (0.0237)	-0.4750 *** (0.0405)	0.5281 *** (0.0392)	3.0627 *** (0.1495)	-
Denmark	-4.5E-05 (4.1E-05)	1.0000 *** (0.0000)	1.0000 *** (0.0000)	0.5051 *** (0.0114)	0.6319 *** (0.0188)	0.3446 (0.0407)	-0.2553 *** (0.0290)	0.5460 *** (0.0175)	2.5852 *** (0.0973)	-
Finland	0.0003 (4.9E-04)	0.0958 ** (0.0428)	0.0958 ** (0.0428)	0.5392 *** (0.1859)	0.6321 *** (0.2000)	0.6321 (0.1915)	-0.1162 (0.0900)	2.1773 *** (0.2192)	-	-

Table 3.8 : Estimation results of the AR(1)-FIAPARCH(1,d,1) (Continued)

	Mean Equation					Variance Equation					Student (df)	G.E.D ( $\tau$ )
	Cst ( $\alpha_0$ )	AR(1)	Cst ( $\alpha_0$ )	d-Figarch	ARCH ( $\phi$ )	GARCH ( $\beta$ )	APARCH ( $\gamma$ )	APARCH ( $\delta$ )				
France	0.0004 (0.0011)	0.1914 (0.0334)	0.9147 (0.8887)	0.7236 (0.1843)	0.4845 (0.1424)	0.8189 (0.0847)	-0.3096 (0.1078)	1.8632 (0.1907)	***	-	-	
Germany	-1.2E-05 (0.0006)	0.1239 (0.0407)	0.0000 (366.19)	0.7854 (0.4769)	0.2904 (0.4486)	0.8039 (0.1384)	0.0185 (0.1381)	2.3219 (0.5546)	***	-	-	
Ireland	3.1E-06 (1.2E-05)	0.5931 (0.0012)	0.6048 (3.0596)	0.5984 (0.1278)	0.5132 (0.1078)	0.7446 (0.0709)	-0.4985 (0.1279)	0.9510 (0.0957)	***	-	0.8050 (0.1512)	
Italy	4.0E-06 (4.0E-05)	-0.0150 (0.0002)	28.9289 (9.3825)	0.2371 (0.0369)	0.0999 (0.3112)	0.2421 (0.2950)	0.5267 (0.0727)	1.8154 (0.1997)	***	-	0.4207 (0.0172)	
Japan	4.2E-06 (2.8E-05)	-0.1754 (0.0015)	2.9038 (2.1909)	0.4586 (0.0194)	0.1235 (0.0632)	0.4793 (0.0653)	-0.2276 (0.1035)	1.1998 (0.0477)	***	-	0.3499 (0.0147)	
Latvia	0.0008 (0.0002)	1.0000 (0.0000)	0.8645 (0.1355)	0.1804 (0.0233)	0.3471 (0.0644)	-0.4528 (0.0431)	0.7669 (0.0280)	0.0309 (0.0309)	***	2.3917 (0.0178)	-	
Lithuania	0.0010 (0.0214)	1.0000 (0.0000)	0.9963 (1.5096)	0.2129 (0.0148)	0.5767 (0.0311)	0.0455 (0.0076)	0.1362 (0.0244)	0.3717 (0.0122)	***	2.5459 (0.0528)	-	
Netherlands	-0.0007 (0.0002)	0.9958 (0.0010)	0.4748 (0.0270)	0.6730 (0.1983)	0.4273 (0.1432)	0.2205 (0.0510)	0.5973 (0.0234)	1.3690 (0.1113)	***	5.5211 (0.4420)	-	
Portugal	2.5E-06 (0.0001)	-0.0030 (0.0002)	7.6097 (0.1962)	0.8289 (0.0628)	0.6103 (0.0542)	0.4807 (0.0190)	0.3632 (0.1372)	1.9409 (0.0608)	***	-	0.2870 (0.0129)	
Slovakia	-0.0004 (0.0006)	0.0100 (0.0437)	78.2647 (157.92)	0.6446 (0.1089)	0.3152 (0.1490)	0.6794 (0.1388)	-0.1810 (0.0898)	2.0817 (0.2664)	***	-	-	
Slovenia	0.0001 (1.9E-05)	0.7297 (0.0502)	56.5384 (103.00)	0.7847 (0.0541)	0.0983 (0.0764)	0.4199 (0.0800)	0.3005 (0.1040)	0.8035 (0.1498)	***	-	0.5497 (0.1761)	
Spain	1.0E-06 (1.1E-05)	0.0017 (0.0028)	0.2929 (0.0560)	0.3499 (0.0204)	0.2038 (0.0671)	0.4288 (0.0702)	-0.8369 (0.0540)	1.3025 (0.0666)	***	2.8175 (0.0664)	-	
Sweden	-0.0016 (0.0006)	** (0.0000)	0.9497 (0.3799)	0.4985 (0.0127)	0.4875 (0.0308)	0.5810 (0.0209)	0.4466 (0.0352)	0.4208 (0.0171)	***	3.1075 (0.2523)	-	
Philippines	-2.0E-06 (1.5E-05)	0.9359 (0.0386)	0.0035 (0.0001)	0.1621 (0.0237)	0.0006 (0.0785)	0.1602 (0.0643)	0.6934 (0.3209)	1.5075 (0.0425)	***	9.2233 (2.1216)	-	
Turkey	-0.0001 (4.9E-05)	0.1172 (0.0253)	1.4295 (495.05)	0.9945 (0.0046)	0.1632 (0.0252)	0.9096 (0.0091)	-0.1958 (0.1055)	1.1906 (0.2343)	***	4.4236 (0.2202)	-	
Bulgaria	-0.0006 (0.0004)	0.1181 (0.0404)	0.0146 (0.1077)	0.3142 (0.1370)	0.3050 (0.1369)	0.3755 (0.1222)	-0.1885 (0.1079)	2.2343 (0.1983)	***	-	-	



Table 3.8 : Estimation results of the AR(1)-FIAPARCH(1,d,1) (Continued)

	Mean Equation			Variance Equation										Student ( <i>df</i> )	G.E.D ( <i>r</i> )
	Cst ( $\alpha_0$ )	AR(1)	Cst ( $\alpha_0$ )	d-Figarch	ARCH ( $\phi$ )	GARCH ( $\beta$ )	APARCH ( $\gamma$ )	APARCH ( $\delta$ )	APARCH ( $\beta$ )	APARCH ( $\gamma$ )	APARCH ( $\delta$ )	APARCH ( $\beta$ )	APARCH ( $\gamma$ )		
Croatia	-0.0006 (0.0003)	** (0.0280)	0.0393 (0.1356)	0.4667 (0.1274)	*** (0.1759)	0.5412 (0.1387)	*** (0.7003)	-0.1181 (0.0890)	1.9222 (0.1266)	***	-	-	-	-	
Czech	-9.0E-06 (2.4E-05)	*** (0.0027)	1.0048 (1.2575)	0.6785 (0.0473)	*** (0.0369)	0.4933 (0.0720)	*** (0.6371)	-0.3313 (0.0474)	*** (0.1370)	0.9161 (0.1370)	***	-	-	0.3628 (0.0156)	
Hungary	-2.0E-06 (4.5E-05)	*** (0.0020)	18.1272 (2.8926)	0.7805 (0.0204)	*** (0.0224)	0.5517 (0.0224)	*** (0.8093)	0.9226 (0.0231)	*** (0.0501)	2.4153 (0.0501)	***	-	-	0.3704 (0.0208)	
Greece	-8.0E-06 (1.5E-05)	*** (0.0251)	12.2720 (16.58)	0.7346 (0.1396)	*** (0.0811)	0.3918 (0.0811)	*** (0.4788)	-0.3299 (0.0365)	*** (0.3447)	0.9905 (0.3447)	***	-	-	0.7215 (0.0359)	
Poland	-0.0003 (0.0001)	*** (0.0171)	0.0000 (0.0384)	0.5332 (0.0476)	*** (0.0745)	0.2019 (0.0745)	*** (0.4802)	-0.3219 (0.1035)	*** (0.0756)	1.6923 (0.0756)	***	2.9626 (0.1053)	-	-	
Romania	-0.0003 (0.0004)	*** (0.0413)	5.4566 (9.1640)	0.6071 (0.1411)	*** (0.0913)	0.7873 (0.0913)	*** (0.9508)	-0.3709 (0.1252)	*** (0.0033)	2.0033 (0.0980)	***	-	-	-	
Ukraine	1.5E-06 (5.0E-06)	*** (0.0409)	0.0000 (0.0364)	0.8731 (0.0311)	*** (0.1012)	0.1905 (0.1012)	* (0.5730)	-0.0804 (0.0387)	** (0.0409)	1.1093 (0.0409)	***	4.6197 (1.6281)	-	-	

\*, \*\* and \*\*\* refer to significance at respectively 10%, 5% and 1% statistical levels.

## Annexe D. Results of the structural breaks test

TABLE D.9: Thresholds F-statistics (0 Vs. 1 test)

Country	F-statistic	Scaled F-statistic	
<i>Panel A : Oil-producing countries</i>			
Norway	38.60	463.17	**
UK	17.86	232.23	**
USA	34.78	452.16	**
Brazil	13.97	181.60	**
China	7.66	99.62	**
Mexico	16.50	214.53	**
Qatar	13.03	143.28	**
Thailand	11.70	152.13	**
Indonesia	3.83	49.79	**
Russia	11.44	148.67	**
Venezuela	24.13	265.47	**
<i>Panel B : Other worldwide countries</i>			
Austria	21.74	282.60	**
Belgium	14.84	192.92	**
Denmark	26.37	342.81	**
Finland	16.33	212.30	**
France	42.33	550.27	**
Germany	43.00	558.94	**
Ireland	24.69	320.95	**
Italy	17.68	229.82	**
Japan	37.61	488.97	**
Latvia	8.63	112.13	**
Lithuania	7.12	92.59	**
Netherlands	34.47	448.08	**
Portugal	21.49	279.41	**

Slovakia	10.16	132.12	**
Slovenia	10.65	138.51	**
Spain	30.35	394.60	**
Sweden	20.34	264.47	**
Philippines	21.81	283.55	**
Turkey	32.52	422.71	**
Bulgaria	8.71	113.26	**
Croatia	16.05	208.65	**
Czech	14.58	189.56	**
Hungary	10.60	137.79	**
Greece	174.22	2264.90	**
Poland	8.66	112.60	**
Romania	9.10	118.35	**
Ukraine	12.46	161.98	**

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This table reports the results of the structural breaks test proposed by [62]. The test investigates the presence of a regime-switching under the null hypothesis of zero thresholds (one-regime). A maximum of one threshold and a 15% trimming percentage are authorized. The Bai-Perron critical value is equal to 27.03. \*\* denotes statistical significance at the 5% level.

### **Annexe E. SETAR(1) results**

TABLE E.10: Estimation results of the SETAR(1) for oil-consuming countries

T. variable T. value	Austria				Belgium				Denmark				Finland				France		
	$VOL_t - 1$		$VOL_t - 3$		$VOL_t - 4$		$VOL_t - 1$		$VOL_t - 1$		$VOL_t - 1$		$VOL_t - 1$		$VOL_t - 2$				
	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2			
Obs.	2467	438	1472	431	2445	432	2425	482	2481	439									
C	0.0007 (0.0004)	-0.0040 (0.0015)	0.0000 (0.0001)	-0.0002 (0.0001)	0.0000 (0.0004)	-0.0025 (0.0009)	0.0001 (0.0005)	-0.0035 (0.0014)	0.0050 (0.0036)	-0.0088 (0.0124)	0.0000 (0.0005)	-0.0035 (0.0014)	0.0050 (0.0036)	-0.0088 (0.0124)	0.0000 (0.0005)	-0.0035 (0.0014)	0.0050 (0.0036)		
$Vol_t - 1$	0.7745 (0.0212)	0.6492 (0.0167)	1.4089 (0.0373)	0.9259 (0.0066)	1.0820 (0.0917)	0.3661 (0.0198)	0.4911 (0.0205)	0.7488 (0.0208)	0.7257 (0.0378)	0.2803 (0.0193)	0.4911 (0.0205)	0.7488 (0.0208)	0.7257 (0.0378)	0.2803 (0.0193)	0.4911 (0.0205)	0.7488 (0.0208)	0.7257 (0.0378)		
SMR	0.0035 (0.0021)	-0.0036 (0.0060)	-0.0002 (0.0005)	-0.0015 (0.0004)	-0.0040 (0.0024)	0.0161 (0.0036)	0.0016 (0.0033)	0.0042 (0.0050)	-0.0046 (0.0212)	-0.0285 (0.0497)	0.0016 (0.0033)	0.0042 (0.0050)	-0.0046 (0.0212)	-0.0285 (0.0497)	0.0016 (0.0033)	0.0042 (0.0050)	-0.0046 (0.0212)		
RBY	0.0000 (0.0002)	0.0065 (0.0020)	0.0000 (0.0000)	0.0001 (0.0001)	0.0000 (0.0001)	-0.0005 (0.0003)	0.0000 (0.0002)	0.0007 (0.0007)	-0.0006 (0.0013)	0.0577 (0.0250)	0.0000 (0.0002)	0.0007 (0.0007)	-0.0006 (0.0013)	0.0577 (0.0250)	0.0000 (0.0002)	0.0007 (0.0007)	-0.0006 (0.0013)		
RGDP	-0.0389 (0.0513)	0.8920 (0.1340)	-0.0127 (0.0437)	0.1588 (0.0508)	-0.0020 (0.0469)	-0.0047 (0.1326)	-0.3530 (0.2840)	0.0080 (0.4876)	1.3847 (2.3898)	73.2032 (14.4836)	-0.3530 (0.2840)	0.0080 (0.4876)	1.3847 (2.3898)	73.2032 (14.4836)	-0.3530 (0.2840)	0.0080 (0.4876)	1.3847 (2.3898)	73.2032 (14.4836)	
RDEBT	-0.1339 (0.2009)	0.5229 (0.4537)	-0.0008 (0.0150)	-0.0169 (0.0174)	0.0046 (0.0120)	-0.2304 (0.0256)	-0.0037 (0.0274)	0.0950 (0.0455)	4.0723 (3.7942)	43.2009 (14.8959)	-0.0037 (0.0274)	0.0950 (0.0455)	4.0723 (3.7942)	43.2009 (14.8959)	-0.0037 (0.0274)	0.0950 (0.0455)	4.0723 (3.7942)	43.2009 (14.8959)	
REDEBT	0.1271 (0.2712)	-0.7624 (0.6255)	-0.0020 (0.0062)	0.0007 (0.0079)	0.0045 (0.0042)	0.1308 (0.0111)	0.0064 (0.0454)	0.0672 (0.1415)	0.1660 (0.4213)	4.7704 (9.3245)	0.0064 (0.0454)	0.0672 (0.1415)	0.1660 (0.4213)	4.7704 (9.3245)	0.0064 (0.0454)	0.0672 (0.1415)	0.1660 (0.4213)	4.7704 (9.3245)	
INF	-0.0377 (0.1418)	0.8552 (0.3669)	0.0041 (0.0093)	0.0036 (0.0091)	0.0307 (0.1645)	-0.5027 (0.3887)	0.1116 (0.2632)	1.6386 (5.587)	1.0174 (1.5256)	32.4333 (4.8469)	0.1116 (0.2632)	1.6386 (5.587)	1.0174 (1.5256)	32.4333 (4.8469)	0.1116 (0.2632)	1.6386 (5.587)	1.0174 (1.5256)	32.4333 (4.8469)	
RCCI	-0.0001 (0.0002)	-0.0002 (0.0004)	1.46E-05 (2.87E-05)	-1.30E-08 (2.86E-05)	1.91E-05 (0.0002)	-0.0001 (0.0002)	-0.0001 (0.0004)	-0.0001 (0.0005)	0.2662 (0.3219)	-1.1384 (0.6068)	-0.0001 (0.0004)	-0.0001 (0.0005)	0.2662 (0.3219)	-1.1384 (0.6068)	-0.0001 (0.0004)	-0.0001 (0.0005)	0.2662 (0.3219)	-1.1384 (0.6068)	
RTRGI	-1.25E-06 (2.18E-06)	3.93E-05 (0.0000)	3.30E-08 (3.45E-07)	9.09E-07 (3.40E-07)	-1.03E-06 (1.94E-06)	2.19E-05 (5.41E-06)	-1.56E-06 (2.78E-06)	*** (6.43E-06)	*** (1.93E-05)	0.0004 (0.0001)	*** (2.78E-06)	*** (6.43E-06)	*** (1.93E-05)	0.0004 (0.0001)	*** (2.78E-06)	*** (6.43E-06)	*** (1.93E-05)	0.0004 (0.0001)	0.0006 (0.0002)
VIX	1.94E-05 (7.44E-06)	0.0001 (2.14E-05)	1.03E-06 (0.0000)	4.32E-06 (1.23E-06)	*** (6.49E-06)	0.0001 (1.29E-05)	*** (1.10E-05)	0.0001 (1.97E-05)	*** (0.0001)	0.0006 (0.0002)	*** (1.10E-05)	0.0001 (1.97E-05)	*** (0.0001)	0.0006 (0.0002)	*** (1.10E-05)	0.0001 (1.97E-05)	0.0006 (0.0002)	0.0006 (0.0002)	0.0006 (0.0002)
RWTI	-0.0013 (0.0015)	-0.0058 (0.0046)	-0.0001 (0.0002)	-0.0006 (0.0002)	-0.0017 (0.0014)	-0.0028 (0.0024)	-0.0012 (0.0022)	0.0039 (0.0036)	-0.0004 (0.0137)	-0.0901 (0.0417)	-0.0012 (0.0022)	0.0039 (0.0036)	-0.0004 (0.0137)	-0.0901 (0.0417)	-0.0012 (0.0022)	0.0039 (0.0036)	-0.0004 (0.0137)	-0.0901 (0.0417)	-0.0901 (0.0417)
OVX	-1.11E-05 (3.99E-06)	*** (1.75E-05)	-4.37E-08 (5.42E-07)	-8.93E-07 (7.56E-07)	1.56E-06 (2.87E-06)	-2.76E-05 (7.90E-06)	-2.50E-06 (4.87E-06)	*** (1.48E-05)	-4.75E-05 (3.40E-05)	-0.0001 (0.0002)	*** (1.48E-05)	*** (1.48E-05)	-4.75E-05 (3.40E-05)	-0.0001 (0.0002)	*** (1.48E-05)	*** (1.48E-05)	-4.75E-05 (3.40E-05)	-0.0001 (0.0002)	-0.0001 (0.0002)

TABLE E.10: Estimation results of the SETAR(1) for oil-consuming countries (*Continued*)

T. variable	Germany						Ireland						Italy						Japan						Latvia			
	VOL <sub>t-2</sub>			VOL <sub>t-2</sub>			VOL <sub>t-2</sub>			VOL <sub>t-2</sub>			VOL <sub>t-2</sub>			VOL <sub>t-2</sub>			VOL <sub>t-2</sub>			VOL <sub>t-4</sub>			VOL <sub>t-4</sub>			
	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2		
Obs.	2454	432	1811	434	2494	440	2476	453	2491	439	2491	439	2491	439	2491	439	2491	439	2491	439	2491	439	2491	439	2491	439		
C	-0.0012	0.0741	***	0.0004	0.0194	0.0003	0.0003	***	0.0003	0.0003	***	0.0003	0.0003	***	0.0003	0.0003	***	0.0003	0.0003	***	0.0003	0.0003	***	0.0003	0.0003	***		
	(0.0061)	(0.0162)		(0.0285)	(0.0007)	(0.0016)	(0.0004)		(0.0004)	(0.0004)		(0.0004)	(0.0012)		(0.0004)	(0.0004)		(0.0004)	(0.0004)		(0.0004)	(0.0013)		(0.0013)	(0.0031)			
V <sub>o</sub> <sub>t-1</sub>	1.5377	***	0.8852	1.9770	***	0.6222	***	0.4912	***	0.4831	***	0.6854	***	0.6854	***	0.6854	***	0.6854	***	0.6854	***	0.6854	***	0.6854	***	0.6854	***	
	(0.0401)	(0.0118)	(0.9345)	(0.0650)	(0.0369)	(0.0160)	(0.0333)	(0.0185)	(0.0185)	(0.0185)	(0.0185)	(0.0185)	(0.0185)	(0.0185)	(0.0185)	(0.0185)	(0.0185)	(0.0185)	(0.0185)	(0.0185)	(0.0185)	(0.0185)	(0.0185)	(0.0185)	(0.0185)	(0.0185)	(0.0185)	
SMR	-0.0105	0.3748	***	-0.0002	-0.0127	0.0812	***	0.0012	***	0.0025	0.0051	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008		
	(0.0369)	(0.0880)	(0.0562)	(0.0670)	(0.0040)	(0.0077)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	
REY	0.0002	0.0140	0.0000	0.0103	0.0000	0.0032	*	0.0000	*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
	(0.0020)	(0.0211)	(0.0018)	(0.0445)	(0.0005)	(0.0017)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	
RGDP	0.4539	-33.6538	***	-0.0076	-34.4161	0.0861	0.0861	0.0949	*	0.0949	0.0949	0.0949	0.0949	0.0949	0.0949	0.0949	0.0949	0.0949	0.0949	0.0949	0.0949	0.0949	0.0949	0.0949	0.0949	0.0949	0.0949	
	(1.5736)	(4.8163)	(0.8803)	(5.3309)	(0.6176)	(1.4887)	(0.6176)	(0.6176)	(0.6176)	(0.6176)	(0.6176)	(0.6176)	(0.6176)	(0.6176)	(0.6176)	(0.6176)	(0.6176)	(0.6176)	(0.6176)	(0.6176)	(0.6176)	(0.6176)	(0.6176)	(0.6176)	(0.6176)	(0.6176)	(0.6176)	(0.6176)
RDEBT	-0.2121	1.6266	0.1123	12.6201	***	-0.1883	0.0087	0.0087	0.0087	0.0087	0.0087	0.0087	0.0087	0.0087	0.0087	0.0087	0.0087	0.0087	0.0087	0.0087	0.0087	0.0087	0.0087	0.0087	0.0087	0.0087	0.0087	
	(1.1673)	(2.8161)	(2.4737)	(3.2414)	(0.2475)	(0.5735)	(0.0777)	(0.0777)	(0.0777)	(0.0777)	(0.0777)	(0.0777)	(0.0777)	(0.0777)	(0.0777)	(0.0777)	(0.0777)	(0.0777)	(0.0777)	(0.0777)	(0.0777)	(0.0777)	(0.0777)	(0.0777)	(0.0777)	(0.0777)	(0.0777)	(0.0777)
REDEBT	-0.5148	-20.0540	***	0.0090	10.4688	0.0528	0.0528	0.0164	0.0164	0.0164	0.0164	0.0164	0.0164	0.0164	0.0164	0.0164	0.0164	0.0164	0.0164	0.0164	0.0164	0.0164	0.0164	0.0164	0.0164	0.0164	0.0164	
	(0.5630)	(2.6034)	(1.0444)	(1.6775)	(0.0705)	(0.1379)	(0.1379)	(0.1379)	(0.1379)	(0.1379)	(0.1379)	(0.1379)	(0.1379)	(0.1379)	(0.1379)	(0.1379)	(0.1379)	(0.1379)	(0.1379)	(0.1379)	(0.1379)	(0.1379)	(0.1379)	(0.1379)	(0.1379)	(0.1379)	(0.1379)	(0.1379)
INF	-0.1083	49.8596	***	-0.0364	11.7209	6.3225	6.3225	0.0745	0.0745	0.0745	0.0745	0.0745	0.0745	0.0745	0.0745	0.0745	0.0745	0.0745	0.0745	0.0745	0.0745	0.0745	0.0745	0.0745	0.0745	0.0745	0.0745	
	(2.2674)	(8.6431)	(3.2062)	(9.3267)	(0.5736)	(1.4568)	(1.4568)	(0.2347)	(0.2347)	(0.2347)	(0.2347)	(0.2347)	(0.2347)	(0.2347)	(0.2347)	(0.2347)	(0.2347)	(0.2347)	(0.2347)	(0.2347)	(0.2347)	(0.2347)	(0.2347)	(0.2347)	(0.2347)	(0.2347)	(0.2347)	(0.2347)
RCCI	0.0000	0.0064	-0.0024	0.0064	0.0482	0.0180	0.0180	0.0240	0.0240	0.0240	0.0240	0.0240	0.0240	0.0240	0.0240	0.0240	0.0240	0.0240	0.0240	0.0240	0.0240	0.0240	0.0240	0.0240	0.0240	0.0240	0.0240	
	(0.0030)	(0.0064)	(0.1695)	(0.3594)	(0.0482)	(0.1296)	(0.1296)	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0240)
RTRGI	4.61E-06	-0.0001	-1.41E-06	-1.87E-05	1.80E-06	1.90E-05	1.90E-05	-1.38E-06	-1.38E-06	-1.38E-06	-1.38E-06	-1.38E-06	-1.38E-06	-1.38E-06	-1.38E-06	-1.38E-06	-1.38E-06	-1.38E-06	-1.38E-06	-1.38E-06	-1.38E-06	-1.38E-06	-1.38E-06	-1.38E-06	-1.38E-06	-1.38E-06	-1.38E-06	-1.38E-06
	(3.21E-05)	(0.0001)	(0.0001)	(0.0002)	(3.87E-06)	(7.98E-06)	(7.98E-06)	(2.49E-06)	(2.49E-06)	(2.49E-06)	(2.49E-06)	(2.49E-06)	(2.49E-06)	(2.49E-06)	(2.49E-06)	(2.49E-06)	(2.49E-06)	(2.49E-06)	(2.49E-06)	(2.49E-06)	(2.49E-06)	(2.49E-06)	(2.49E-06)	(2.49E-06)	(2.49E-06)	(2.49E-06)	(2.49E-06)	(2.49E-06)
VIX	-1.22E-05	0.0009	***	-5.29E-06	-0.0014	0.0002	0.0002	9.94E-06	9.94E-06	9.94E-06	9.94E-06	9.94E-06	9.94E-06	9.94E-06	9.94E-06	9.94E-06	9.94E-06	9.94E-06	9.94E-06	9.94E-06	9.94E-06	9.94E-06	9.94E-06	9.94E-06	9.94E-06	9.94E-06	9.94E-06	9.94E-06
	(0.0001)	(0.0003)	(0.0002)	(0.0005)	(0.0000)	(2.99E-05)	(2.99E-05)	(8.71E-06)	(8.71E-06)	(8.71E-06)	(8.71E-06)	(8.71E-06)	(8.71E-06)	(8.71E-06)	(8.71E-06)	(8.71E-06)	(8.71E-06)	(8.71E-06)	(8.71E-06)	(8.71E-06)	(8.71E-06)	(8.71E-06)	(8.71E-06)	(8.71E-06)	(8.71E-06)	(8.71E-06)	(8.71E-06)	(8.71E-06)
RWTI	-0.0034	-0.3874	***	-0.0005	0.0255	-0.0601	-0.0601	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	
	(0.0234)	(0.0614)	(0.0332)	(0.0542)	(0.0029)	(0.0070)	(0.0070)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)
OVX	-6.01E-06	-0.0016	***	0.0000	-0.0002	-1.34E-05	-2.93E-05	-1.14E-06	-1.14E-06	-1.14E-06	-1.14E-06	-1.14E-06	-1.14E-06	-1.14E-06	-1.14E-06	-1.14E-06	-1.14E-06	-1.14E-06	-1.14E-06	-1.14E-06	-1.14E-06	-1.14E-06	-1.14E-06	-1.14E-06	-1.14E-06	-1.14E-06	-1.14E-06	-1.14E-06
	(0.0001)	(0.0003)	(0.0001)	(0.0002)	(8.44E-06)	(2.32E-05)	(2.32E-05)	(4.02E-06)	(4.02E-06)	(4.02E-06)	(4.02E-06)	(4.02E-06)	(4.02E-06)	(4.02E-06)	(4.02E-06)	(4.02E-06)	(4.02E-06)	(4.02E-06)	(4.02E-06)	(4.02E-06)	(4.02E-06)	(4.02E-06)	(4.02E-06)	(4.02E-06)	(4.02E-06)	(4.02E-06)	(4.02E-06)	(4.02E-06)

TABLE E.10: Estimation results of the SETAR(1) for oil-consuming countries (*Continued*)

T. variable	Lithuania				Netherlands				Portugal				Slovakia				Slovenia			
	VOL <sub>t-2</sub>		VOL <sub>t-4</sub>		VOL <sub>t-5</sub>		VOL <sub>t-1</sub>		VOL <sub>t-5</sub>		VOL <sub>t-1</sub>		VOL <sub>t-1</sub>		VOL <sub>t-1</sub>		VOL <sub>t-1</sub>			
	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2		
Obs.	2488	440	2013	887	2489	442	2427	463	2488	440	2488	463	2488	440	2488	463	2488	440		
C	0.0003 (0.0010)	0.0045 (0.0028)	-0.0002 (0.0003)	0.0009 (0.0005)	* (0.0018)	0.0073 (0.0042)	0.0017 (0.0016)	-0.0010 (0.0037)	** (0.0007)	0.0001 (0.0007)	0.0001 (0.0007)	-0.0001 (0.0037)	** (0.0007)	0.0001 (0.0007)	0.0001 (0.0007)	-0.0001 (0.0037)	** (0.0007)	0.0001 (0.0007)	0.0010 (0.0023)	
VOL <sub>t-1</sub>	0.6364 (0.0385)	*** (0.0173)	0.5008 (0.0203)	*** (0.0223)	0.7743 (0.0203)	*** (0.0223)	0.4479 (0.0252)	*** (0.0252)	0.2354 (0.0252)	*** (0.0252)	1.4113 (0.2755)	*** (0.2755)	0.5306 (0.170)	*** (0.170)	0.8943 (0.1782)	*** (0.1782)	0.7766 (0.0121)	*** (0.0121)	0.7766 (0.0121)	
SMR	0.0006 (0.0086)	-0.0379 (0.0116)	*** (0.0023)	0.0007 (0.0028)	-0.0017 (0.0023)	0.0007 (0.0028)	-0.0160 (0.0120)	0.0244 (0.0247)	0.0001 (0.0247)	0.0001 (0.0247)	0.0051 (0.0098)	0.0456 (0.0271)	*	0.0051 (0.0098)	-0.0010 (0.0050)	0.0252 (0.0050)	*** (0.0050)	0.0252 (0.0050)	0.0252 (0.0050)	
REY	3.64E-05 (0.0006)	0.0006 (0.0012)	1.01E-06 (0.0001)	0.0001 (0.0003)	0.0107 (0.0045)	0.0133 (0.0138)	** (0.0045)	0.0107 (0.0138)	0.0001 (0.0045)	0.0001 (0.0045)	0.0001 (0.0045)	0.0001 (0.0045)	0.0001 (0.0045)	0.0001 (0.0045)	0.0001 (0.0045)	0.0001 (0.0045)	0.0001 (0.0045)	0.0001 (0.0045)	0.0001 (0.0045)	
RGDP	0.0128 (0.0578)	-0.0980 (0.1563)	0.1058 (0.2800)	1.7230 (0.4152)	*** (0.4767)	7.3111 (1.3285)	-0.2354 (0.4767)	0.0107 (0.4767)	0.0107 (0.4767)	0.0107 (0.4767)	0.0107 (0.4767)	0.0107 (0.4767)	0.0107 (0.4767)	0.0107 (0.4767)	0.0107 (0.4767)	0.0107 (0.4767)	0.0107 (0.4767)	0.0107 (0.4767)	0.0107 (0.4767)	0.0107 (0.4767)
RDEBT	0.0335 (0.0746)	-0.7162 (0.2482)	*** (0.0447)	0.3018 (0.0695)	*** (0.0695)	-0.1446 (0.0695)	** (0.1987)	-0.0077 (0.1987)	** (0.1987)	-0.0077 (0.1987)	-0.0077 (0.1987)	-0.0077 (0.1987)	** (0.1987)	-0.0077 (0.1987)	-0.0077 (0.1987)	-0.0077 (0.1987)	-0.0077 (0.1987)	-0.0077 (0.1987)	-0.0077 (0.1987)	-0.0077 (0.1987)
REDEBT	0.1123 (0.1300)	1.5889 (0.6228)	** (0.0331)	-0.0124 (0.0478)	0.0989 (0.0478)	0.0989 (0.0478)	** (0.4964)	-0.1657 (0.4964)	** (0.4964)	-0.1657 (0.4964)	0.1086 (0.0761)	0.1454 (0.1315)	0.1086 (0.1315)	0.1454 (0.1315)	0.1086 (0.1315)	0.1454 (0.1315)	0.1086 (0.1315)	0.1454 (0.1315)	0.1086 (0.1315)	0.1454 (0.1315)
INF	0.1360 (0.3282)	1.5855 (0.6981)	** (0.0928)	-0.0611 (0.1334)	-0.0655 (0.1334)	-0.0655 (0.1334)	** (0.4782)	0.5094 (0.4782)	** (0.4782)	0.5094 (0.4782)	0.4916 (0.7450)	0.4916 (2.4805)	-4.4028 (2.4805)	*	-0.0090 (0.1969)	-0.0490 (0.6040)	-0.0090 (0.1969)	-0.0490 (0.6040)	-0.0090 (0.1969)	-0.0490 (0.6040)
RCCI	0.0001 (0.0007)	-0.0172 (0.0200)	-4.67E-05 (0.0001)	4.22E-05 (0.0005)	0.0402 (0.0005)	0.0402 (0.0005)	** (0.0173)	0.0402 (0.0173)	** (0.0173)	0.0402 (0.0173)	0.0001 (0.0025)	0.0001 (0.0025)	0.0001 (0.0025)	0.0001 (0.0025)	0.0001 (0.0025)	0.0001 (0.0025)	0.0001 (0.0025)	0.0001 (0.0025)	0.0001 (0.0025)	0.0001 (0.0025)
RTRGI	-1.92E-06 (5.15E-06)	-1.97E-05 (1.53E-05)	6.38E-08 (1.66E-06)	-5.84E-06 (2.81E-06)	** (2.81E-06)	2.19E-05 (9.80E-06)	** (9.80E-06)	2.19E-05 (9.80E-06)	** (9.80E-06)	2.19E-05 (9.80E-06)	1.82E-05 (8.37E-06)	1.82E-05 (8.37E-06)	1.82E-05 (8.37E-06)	1.82E-05 (8.37E-06)	1.82E-05 (8.37E-06)	1.82E-05 (8.37E-06)	1.82E-05 (8.37E-06)	1.82E-05 (8.37E-06)	1.82E-05 (8.37E-06)	1.82E-05 (8.37E-06)
VIX	2.71E-05 (2.08E-05)	0.0001 (3.60E-05)	*** (6.33E-05)	2.70E-05 (8.93E-06)	*** (8.93E-06)	2.70E-05 (8.93E-06)	*** (3.52E-05)	2.70E-05 (3.52E-05)	*** (3.52E-05)	2.70E-05 (3.52E-05)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)
RWTI	-2.19E-05 (0.0041)	-0.0353 (0.0059)	*** (0.0013)	-0.0017 (0.0020)	-0.0017 (0.0020)	-0.0017 (0.0020)	0.0036 (0.0069)	0.0036 (0.0069)	0.0036 (0.0069)	0.0036 (0.0069)	-0.0332 (0.0174)	-0.0332 (0.0174)	-0.0332 (0.0174)	*	0.0002 (0.0054)	0.0002 (0.0108)	0.0002 (0.0054)	0.0002 (0.0108)	0.0002 (0.0054)	0.0002 (0.0108)
OVX	-6.61E-06 (9.62E-06)	-0.0001 (3.08E-05)	*** (3.01E-06)	-4.61E-06 (5.04E-06)	*** (5.04E-06)	-4.61E-06 (5.04E-06)	*** (1.64E-05)	-4.61E-06 (1.64E-05)	*** (1.64E-05)	-4.61E-06 (1.64E-05)	-0.0003 (0.0001)	-0.0003 (0.0001)	-0.0003 (0.0001)	*** (4.83E-05)	6.43E-06 (6.33E-06)	6.43E-06 (6.33E-06)	6.43E-06 (6.33E-06)	6.43E-06 (6.33E-06)	6.43E-06 (6.33E-06)	6.43E-06 (6.33E-06)

TABLE E.10: Estimation results of the SETAR(1) for oil-consuming countries (*Continued*)

T. variable	Spain						Philippines						Turkey						Bulgaria			
	VOL <sub>t-2</sub>			VOL <sub>t-1</sub>			VOL <sub>t-1</sub>			VOL <sub>t-2</sub>			VOL <sub>t-2</sub>			VOL <sub>t-3</sub>			VOL <sub>t-3</sub>			
	Regime 1	Regime 2	0.0006	Regime 1	Regime 2	0.0007	Regime 1	Regime 2	0.0018	Regime 1	Regime 2	0.0011	Regime 1	Regime 2	0.0011	Regime 1	Regime 2	0.0015	Regime 1	Regime 2		
Obs.	1209	721	2468	2468	440	2491	2491	443	2493	441	2344	2344	441	2344	441	2344	2344	589	589	589		
C	-0.0004 (0.0019)	0.0017 (0.0015)	0.0001 (0.0002)	0.0001 (0.0005)	0.0001 (0.0005)	0.0001 (0.0005)	2.76E-05 (0.0015)	-0.0137 (0.0037)	0.0002 (0.0002)	-0.0013 (0.0005)	0.0002 (0.0005)	0.0002 (0.0005)	0.0002 (0.0005)	0.0002 (0.0005)	0.0002 (0.0005)	0.0002 (0.0005)	0.0002 (0.0005)	-0.0013 (0.0034)	0.0002 (0.0034)	0.0002 (0.0034)	-0.0075 (0.0034)	
V <sub>o</sub> L <sub>t-1</sub>	2.2998 (0.0769)	*** (0.0103)	0.7907 (0.1007)	*** (0.0232)	0.1755 (0.0232)	*** (0.0232)	1.4865 (0.2311)	0.0492 (0.0205)	*** (0.0205)	0.4738 (0.0184)	*** (0.0184)	0.3296 (0.0323)	*** (0.0323)	0.0931 (0.0229)	*** (0.0229)	0.0931 (0.0229)	0.0931 (0.0229)	0.0519 (0.0297)	*** (0.0297)	0.0519 (0.0297)	0.0519 (0.0297)	0.0519 (0.0297)
SMR	-0.0021 (0.0102)	-0.0036 (0.0072)	0.0022 (0.0013)	* (0.0021)	0.0029 (0.0021)	0.0022 (0.0021)	0.0248 (0.0081)	0.0404 (0.0149)	*** (0.0149)	-0.0047 (0.0011)	*** (0.0011)	-0.0047 (0.0011)	*** (0.0011)	0.0285 (0.0133)	*** (0.0133)	0.0285 (0.0133)	0.0285 (0.0133)	0.1391 (0.0167)	*** (0.0167)	0.1391 (0.0167)	0.1391 (0.0167)	0.1391 (0.0167)
REY	0.0003 (0.0009)	0.0003 (0.0012)	0.0000 (0.0001)	0.0000 (0.0002)	0.0002 (0.0002)	0.0000 (0.0002)	-0.0015 (0.0034)	0.0434 (0.0080)	*** (0.0080)	0.0002 (0.0003)	*** (0.0003)	0.0002 (0.0003)	*** (0.0003)	-0.0003 (0.0029)	*** (0.0029)	-0.0003 (0.0029)	-0.0003 (0.0029)	-0.0078 (0.0085)	*** (0.0085)	-0.0078 (0.0085)	-0.0078 (0.0085)	-0.0078 (0.0085)
RGDP	0.1815 (0.0770)	0.0819 (0.0012)	0.0168 (0.0001)	0.0168 (0.0002)	0.1152 (0.0428)	0.0168 (0.0428)	-0.0436 (0.0597)	0.1940 (0.1359)	*	0.2472 (0.0287)	*** (0.0287)	0.0170 (0.0287)	*** (0.0287)	0.0126 (0.0508)	*** (0.0508)	0.0126 (0.0508)	0.0126 (0.0508)	0.2428 (0.1110)	*** (0.1110)	0.2428 (0.1110)	0.2428 (0.1110)	0.2428 (0.1110)
RDEBT	-0.0224 (0.4075)	-0.8593 (0.4162)	** (0.0125)	0.0168 (0.0284)	0.1152 (0.0284)	0.0168 (0.0284)	-0.0436 (0.0510)	0.1940 (0.1154)	*	0.2472 (0.0706)	*** (0.0706)	0.0170 (0.0706)	*** (0.0706)	0.0126 (0.0704)	*** (0.0704)	0.0126 (0.0704)	0.0126 (0.0704)	0.2428 (0.1110)	*** (0.1110)	0.2428 (0.1110)	0.2428 (0.1110)	0.2428 (0.1110)
REDEBT	0.2477 (0.4438)	1.6958 (0.4003)	*** (0.0077)	0.0089 (0.0077)	-0.0206 (0.0110)	0.0089 (0.0110)	-0.1500 (0.6958)	-5.4229 (1.6489)	*	0.1500 (0.0813)	*** (0.0813)	0.0170 (0.0439)	*** (0.0439)	0.1093 (0.1575)	*** (0.1575)	0.1093 (0.1575)	0.1093 (0.1575)	0.5280 (0.3845)	*** (0.3845)	0.5280 (0.3845)	0.5280 (0.3845)	0.5280 (0.3845)
INF	0.1392 (0.5461)	0.5522 (0.4801)	0.0670 (0.0883)	-0.1891 (0.2381)	-0.1891 (0.2381)	-0.1891 (0.2381)	-0.8323 (0.5986)	0.8563 (1.8880)	*	0.8563 (0.0462)	*** (0.0462)	0.0813 (0.0462)	*** (0.0462)	0.8735 (0.5065)	*** (0.5065)	0.8735 (0.5065)	0.8735 (0.5065)	1.0385 (1.0326)	*	1.0385 (1.0326)	1.0385 (1.0326)	1.0385 (1.0326)
RCCI	-0.0002 (0.0015)	0.0001 (0.0007)	-0.0089 (0.0095)	-0.0089 (0.0095)	-0.0686 (0.0199)	-0.0686 (0.0199)	0.0005 (0.0022)	-0.0171 (0.0171)	*** (0.0171)	-0.0019 (0.0222)	*** (0.0222)	-0.0019 (0.0222)	*** (0.0222)	-0.0623 (0.0882)	*** (0.0882)	-0.0623 (0.0882)	-0.0623 (0.0882)	0.4091 (0.1785)	** (0.1785)	0.4091 (0.1785)	0.4091 (0.1785)	0.4091 (0.1785)
RTRGI	5.67E-08 (1.04E-05)	-6.76E-06 (8.45E-06)	1.09E-06 (1.09E-06)	2.28E-06 (2.87E-06)	2.28E-06 (2.87E-06)	2.28E-06 (2.87E-06)	-1.80E-06 (8.06E-06)	0.0001 (2.12E-05)	*** (1.10E-06)	-4.11E-07 (1.39E-05)	*** (1.39E-05)	-4.11E-07 (1.39E-05)	*** (1.39E-05)	-1.53E-06 (8.86E-06)	*** (8.86E-06)	-1.53E-06 (8.86E-06)	-1.53E-06 (8.86E-06)	4.24E-05 (1.82E-05)	** (1.82E-05)	4.24E-05 (1.82E-05)	4.24E-05 (1.82E-05)	4.24E-05 (1.82E-05)
VIX	5.06E-06 (4.78E-05)	3.85E-05 (2.26E-05)	* (3.92E-05)	3.73E-05 (7.53E-06)	3.73E-05 (7.53E-06)	3.73E-05 (7.53E-06)	0.0001 (2.31E-05)	0.0005 (4.87E-05)	** (4.87E-05)	1.47E-05 (4.50E-06)	*** (4.50E-06)	1.47E-05 (4.50E-06)	*** (4.50E-06)	0.0001 (3.47E-05)	*** (3.47E-05)	0.0001 (3.47E-05)	0.0001 (3.47E-05)	0.0003 (0.0001)	*** (0.0001)	0.0003 (0.0001)	0.0003 (0.0001)	0.0003 (0.0001)
RWTI	-0.0023 (0.0067)	0.0004 (0.0053)	0.0004 (0.0008)	0.0004 (0.0017)	0.0078 (0.0017)	0.0004 (0.0017)	0.0026 (0.0047)	0.0246 (0.0088)	*** (0.0088)	-0.0002 (0.0008)	*** (0.0008)	-0.0002 (0.0008)	*** (0.0008)	0.0125 (0.0065)	*** (0.0065)	0.0125 (0.0065)	0.0125 (0.0065)	0.0320 (0.0110)	** (0.0110)	0.0320 (0.0110)	0.0320 (0.0110)	0.0320 (0.0110)
OVX	-3.29E-06 (1.69E-05)	-1.94E-05 (1.36E-05)	** (1.88E-06)	-4.92E-06 (5.38E-06)	-4.92E-06 (5.38E-06)	-4.92E-06 (5.38E-06)	-7.46E-06 (1.15E-05)	-0.0001 (2.39E-05)	*** (2.39E-05)	-3.52E-06 (2.13E-06)	*** (2.13E-06)	-3.52E-06 (2.13E-06)	*** (2.13E-06)	-2.58E-05 (1.52E-05)	*** (1.52E-05)	-2.58E-05 (1.52E-05)	-2.58E-05 (1.52E-05)	-3.62E-05 (4.27E-05)	* (4.27E-05)	-3.62E-05 (4.27E-05)	-3.62E-05 (4.27E-05)	-3.62E-05 (4.27E-05)

TABLE E.10: Estimation results of the SETAR(1) for oil-consuming countries (*Continued*)

T. variable T. value	Croatia				Czech				Hungary				Greece				Poland			
	$VOL_t-2$		$VOL_t-3$		$VOL_t-3$		$VOL_t-3$		$VOL_t-3$		$VOL_t-3$		$VOL_t-3$		$VOL_t-2$		$VOL_t-2$			
	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2		
Obs.	2208	726	2458	440	2493	440	440	638	294	2492	442	442	2492	442	2492	442	2492	442		
C	-0.0026 (0.0008)	*** (0.0011)	-0.0045 (0.0006)	*** (0.0013)	-0.0007 (0.0013)	-0.0061 (0.0033)	-0.0009 (0.0012)	-0.0009 (0.0012)	-0.0003 (0.0002)	-0.0021 (0.0008)	** (0.0019)	-0.0027 (0.0019)	** (0.0019)	-0.0021 (0.0008)	** (0.0019)	-0.0027 (0.0019)	** (0.0019)	-0.0027 (0.0019)		
$Vol_t-1$	2.0911 (0.1188)	*** (0.0152)	0.5518 (0.0388)	*** (0.0159)	0.2574 (0.0225)	0.4644 (0.0257)	0.2574 (0.0225)	11.0991 (0.2183)	*** (0.0043)	0.9426 (0.0399)	*** (0.0137)	0.6944 (0.0137)	*** (0.0137)	0.9426 (0.0399)	*** (0.0137)	0.6944 (0.0137)	*** (0.0137)	0.6944 (0.0137)		
SMR	-0.0114 (0.0067)	* (0.0048)	-0.0070 (0.0038)	0.0045 (0.0051)	0.0743 (0.0076)	0.0517 (0.0132)	0.0743 (0.0076)	-0.0006 (0.0020)	*** (0.0010)	-0.0095 (0.0058)	* (0.0084)	-0.0396 (0.0084)	*** (0.0084)	-0.0095 (0.0058)	* (0.0084)	-0.0396 (0.0084)	*** (0.0084)	-0.0396 (0.0084)		
RBV	-0.0010 (0.0018)	-0.0002 (0.0036)	2.61E-06 (0.0002)	0.0024 (0.0057)	0.0001 (0.0019)	-0.0039 (0.0042)	0.0001 (0.0019)	0.0000 (0.0004)	-0.0002 (0.0002)	0.0010 (0.0038)	*** (0.0108)	0.0422 (0.0108)	*** (0.0108)	0.0010 (0.0038)	*** (0.0108)	0.0422 (0.0108)	*** (0.0108)	0.0422 (0.0108)		
RGDP	-0.0329 (0.0435)	-0.2689 (0.0921)	0.5412 (0.3521)	*** (0.0747)	0.0574 (0.0559)	-0.8231 (0.7476)	0.0574 (0.0559)	-0.0107 (0.0352)	** (0.0172)	-0.0106 (0.0384)	*	-0.2135 (0.1242)	*	-0.0106 (0.0384)	*	-0.2135 (0.1242)	*	-0.2135 (0.1242)		
RDEBT	0.1223 (0.2111)	1.9840 (0.4885)	0.0435 (0.0560)	0.0225 (0.1189)	0.3480 (0.1147)	-0.5910 (0.2790)	0.3480 (0.1147)	0.0647 (0.1632)	** (0.0249)	0.0947 (0.1461)	*** (0.4581)	2.7959 (0.4581)	*** (0.4581)	0.0947 (0.1461)	*** (0.4581)	2.7959 (0.4581)	*** (0.4581)	2.7959 (0.4581)		
REDEBT	-0.0192 (0.0242)	-0.0221 (0.0608)	0.0427 (0.0913)	-0.3907 (0.1514)	0.3049 (0.1516)	-0.3907 (0.1514)	0.3049 (0.1516)	-0.0039 (0.0476)	0.0293 (0.0142)	0.1117 (0.0673)	*	-0.0545 (0.1427)	*	0.1117 (0.0673)	*	-0.0545 (0.1427)	*	-0.0545 (0.1427)		
INF	0.4061 (0.2830)	-0.0182 (0.4926)	0.0913 (0.1776)	-0.6346 (0.3448)	-0.8000 (0.3650)	0.7832 (0.7187)	-0.8000 (0.3650)	-0.0104 (0.0674)	0.1245 (0.0394)	0.1826 (0.4242)	1.9984 (1.2738)	1.9984 (1.2738)	1.9984 (1.2738)	0.1826 (0.4242)	** (0.0284)	1.9984 (1.2738)	** (0.0284)	1.9984 (1.2738)		
RCCI	0.0052 (0.0121)	-0.0181 (0.0134)	0.0002 (0.0004)	-0.0035 (0.0011)	-0.0042 (0.0149)	-0.0013 (0.0438)	-0.0042 (0.0149)	-0.0003 (0.0136)	0.0067 (0.0037)	0.0002 (0.0046)	0.0284 (0.0125)	0.0284 (0.0125)	0.0002 (0.0046)	0.0002 (0.0046)	** (0.0125)	0.0284 (0.0125)	** (0.0125)	0.0284 (0.0125)		
RTRGI	1.47E-05 (4.02E-06)	2.43E-05 (5.51E-06)	-2.57E-06 (3.34E-06)	0.0001 (6.90E-06)	2.36E-07 (7.14E-06)	3.64E-05 (1.65E-05)	2.36E-07 (7.14E-06)	4.54E-06 (6.12E-06)	** (1.28E-06)	1.07E-05 (4.32E-06)	** (8.64E-06)	1.57E-05 (8.64E-06)	** (8.64E-06)	1.07E-05 (4.32E-06)	** (8.64E-06)	1.57E-05 (8.64E-06)	** (8.64E-06)	1.57E-05 (8.64E-06)		
VIX	5.58E-06 (1.46E-05)	0.0001 (1.65E-05)	6.02E-06 (1.18E-05)	0.0001 (2.79E-05)	0.0001 (2.77E-05)	0.0003 (4.56E-05)	0.0001 (2.77E-05)	-5.99E-06 (2.27E-05)	*** (4.07E-06)	0.0001 (1.84E-05)	*** (2.64E-05)	0.0001 (2.64E-05)	*** (2.64E-05)	0.0001 (1.84E-05)	*** (2.64E-05)	0.0001 (2.64E-05)	*** (2.64E-05)	0.0001 (2.64E-05)		
RWTI	-0.0014 (0.0025)	-0.0053 (0.0034)	0.0015 (0.0022)	-0.0014 (0.0050)	-3.30E-05 (0.0053)	0.0276 (0.0103)	-3.30E-05 (0.0053)	0.0004 (0.0034)	0.0276 (0.0103)	0.0004 (0.0034)	0.0004 (0.0034)	0.0004 (0.0034)	0.0004 (0.0034)	0.0004 (0.0034)	0.0004 (0.0034)	0.0004 (0.0034)	0.0004 (0.0034)	0.0004 (0.0034)		
OVX	-7.58E-07 (5.29E-06)	-4.87E-05 (1.16E-05)	-1.60E-06 (5.21E-05)	-1.45E-05 (2.67E-05)	-2.26E-05 (1.25E-05)	-4.99E-05 (3.56E-05)	-2.26E-05 (1.25E-05)	1.23E-05 (1.48E-05)	* (2.37E-06)	-1.86E-07 (7.77E-06)	-1.25E-05 (2.10E-05)	-1.86E-07 (7.77E-06)	-1.25E-05 (2.10E-05)	-1.86E-07 (7.77E-06)	-1.25E-05 (2.10E-05)	-1.86E-07 (7.77E-06)	-1.25E-05 (2.10E-05)	-1.86E-07 (7.77E-06)		



TABLE E.10: Estimation results of the SETAR(1) for oil-consuming countries (*Continued*)

T. variable T. value	Romania			Ukraine		
	VOL <sub>t-4</sub>			VOL <sub>t-4</sub>		
	Regime 1 0.0002	Regime 2	Regime 1 0.0013	Regime 2	Regime 1 0.0013	Regime 2
Obs.	975	206	439	493		
C	0.0002 (0.0002)	0.0003 (0.0008)	-0.0136 (0.0083)	*** (0.0008)	-0.0015 (0.0008)	* (0.0008)
VOL <sub>t-1</sub>	0.5855 (0.0274)	*** (0.0348)	0.7248 (0.0431)	*** (0.0162)	0.6049 (0.0162)	*** (0.0162)
SMR	-0.0002 (0.0010)	-0.0088 (0.0024)	*** (0.0094)	0.0731 (0.0041)	*** (0.0041)	0.0048 (0.0041)
REY	0.0000 (0.0001)	0.0003 (0.0008)	0.0011 (0.0055)	0.0011 (0.0018)	-0.0006 (0.0018)	-0.0006 (0.0018)
RGDP	0.0011 (0.0021)	0.0220 (0.0061)	*** (0.1164)	0.2958 (0.0353)	** (0.0353)	-0.0036 (0.0353)
RDEBT	0.0146 (0.0452)	0.1387 (0.1032)	1.3540 (0.2143)	*** (0.0235)	0.0842 (0.0235)	*** (0.0235)
REDEBT	0.0138 (0.0111)	-0.0903 (0.0288)	*** (0.3708)	-1.9779 (0.1046)	*** (0.1046)	-0.1987 (0.1046)
INF	0.0000 (0.0000)	0.0004 (0.0002)	* (0.5733)	-1.1548 (0.0880)	** (0.0880)	0.0408 (0.0880)
RCCI	0.0003 (0.0016)	-0.0040 (0.0052)	-0.0040 (0.3069)	-0.6113 (0.0697)	** (0.0697)	-0.0052 (0.0697)
RTRGI	-1.08E-06 (8.49E-07)	-3.64E-06 (1.67E-06)	** (2.06E-05)	0.0001 (4.42E-06)	*** (4.42E-06)	0.0000 (4.42E-06)
VIX	5.17E-06 (3.28E-06)	3.93E-05 (7.23E-06)	*** (0.0001)	3.53E-07 (1.55E-05)	4.07E-05 (1.55E-05)	*** (1.55E-05)
RWTI	3.17E-05 (0.0004)	0.0006 (0.0007)	0.0055 (0.0095)	0.0055 (0.0095)	0.0025 (0.0031)	0.0025 (0.0031)
OVX	-6.54E-07 (7.58E-07)	-5.22E-06 (1.93E-06)	*** (2.90E-05)	0.0002 (8.07E-06)	*** (8.07E-06)	1.17E-06 (8.07E-06)

T. variable and T. value refer to the threshold chosen variable and the threshold value used. Regime 1(2) corresponds to the period where Threshold variable chosen < Threshold value (Threshold variable chosen >= Threshold value). \*, \*\* and \*\*\* significance at respectively 10%, 5% and 1% statistical levels.

## Abstract

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The unquenchable thirst of several sectors to crude oil in the recent years makes a common belief regarding its key role towards the acceleration of the recent economic recession and financial instability. This paper aims to examine the nonlinear impact of oil shocks on the sovereign credit risk for a sample of 38 worldwide oil-producing and oil-consuming countries, over a period ranging from January 2006 to March 2017. In contrast to the existing literature, CDS volatility is employed as a measure for the creditworthiness level, rather than the commonly used CDS spreads first-order moment. The methodological framework used in this paper goes beyond previous studies and takes into account more financial data features (long memory behavior, asymmetric effects and nonlinearities) according to a self-exciting regime switching model. Results reveal some dissimilarities in the explanatory power of the exogenous variables between regimes and across countries. Particularly, restricted evidences of the impact of oil shocks on sovereign CDS volatility are detected during the stable regime, whilst during the risky regime credit volatility becomes more sensitive to oil market conditions for most of the studied countries. Overall, the decline in oil price worsens the public finances tenability whether the country is oil-related or not.

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