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THE LONG- AND SHORT-RUN IMPACT OF OIL PRICE CHANGES ON MAJOR GLOBAL ECONOMIES

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Abstract

In the context of the recent slump in global oil prices, the paper investigates the effect of oil price shocks on the economic performance of 51 individual OECD and OPEC economies. We propose an error correction model which allows us to differentiate between short- and long-run price effects. For robustness, structural breaks and potential asymmetries are incorporated. Our approach is particularly interesting, since economic performance is not only measured by GDP, but also by equity indices from the MSCI family. The equity indices provide valuable insights into financial transmission mechanisms, in addition to macroeconomic channels, at much higher frequency than conventional GDP data. We are able to present robust estimates for the severity of oil price shocks for individual economies and thereby identify winners and losers under the current oil price regime.

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Content

1. Introduction

Against the background of the recent slump in oil prices, this paper aims to identify winners and losers under the current price regime. Unlike most literature, we analyze not only the impact of oil price changes on Gross Domestic Product (GDP) as an aggregate macro index for economic performance but also Morgan Stanley Capital Indices (MSCI). The financial data enables us to study the oil price impact on economic performance at a higher frequency than traditional GDP-based studies and to incorporate the investors' perspective as well. The analysis comprises 51 individual Organization for Economic Co-operation and Development (OECD) and Organization of the Petroleum Exporting Countries (OPEC) economies. Therefore our study includes the largest oil producers and consumers globally.

After a decade of rising crude oil prices, the world witnessed a sharp downturn in prices in mid-2008, in parallel with the global financial meltdown. After six years of slow but steady recovery, crude oil again went into continuous decline. A considerable body of academic and non-academic literature is devoted to the relationship between oil prices and economic performance.[1] Among studies there seems to be consent that rising oil prices negatively impact most economies. For instance, Hamilton (1983) states that increasing oil prices where at least partially responsible for all (except 1960) post-WWII recessions in the United States. However, the impact of a continued fall in oil prices is not yet well understood.

Various transmission mechanisms through which oil prices affect economic activity have been identified in the theoretical literature. From the supply side a change in oil prices affects input costs and hence level of production (see Barrow 1984). For oil importers and exporters terms of trade effects result in higher or lower purchasing power of a country-depending on the country being a net importer or exporter and the direction of the oil price change (see Dohner 1981). Oil price changes further affect money demand and as such interest rates as well as inflation (Pierce and Enzler 1974; Brown and Yuecel 2002). While changes in interest rate affect the level of investment, inflation over time affects wages, which are relatively rigid in the short-run. If price changes are long lasting this can lead to structural adjustments and relocation of the workforce to/from oil intensive from/to less oil intensive sectors-potentially resulting in Dutch disease traps for oil exporting economies (Loungani 1986; Corden and Neary 1982). Last but not least, oil prices are indicative of global economic production and hence influence expectation formation of economic agents. What emerges clearly from this list is that channels through which oil prices affect economic activity are multiple and complex and effects differ among oil importing and exporting countries and across different sectors within economies.

From an empirical point of view, many studies identity a significant impact of oil price shocks on a country's economic performance. Several studies focus on the impact of oil price changes on a single economy. Classical work with focus on the US economy was published by Darby (1982) as well as Hamilton (1983). Hamilton concludes that oil price changes are Granger-causal to changes in major macroeconomic variables, such as unemployment and GDP. Additionally, he identifies oil price shocks as an important causal factor for most US

[1] Including: Burbidge and Harrison 1984; Gisser and Goodwin 1986; Mork 1989, 1994; Mork et al. 1994; Lee et al. 1995; Lee et al. 2001; Cologni and Manera 2008; Tong et al. 2010.

recessions from 1949 until 1973. Loscos et al. (2011) provide empirical evidence on the Spanish economy and describe an effect that is changing over time in terms of severity. Similarly, Lutz and Meyer (2009) estimate the oil-economic performance relationship for Germany with comparable structural changes in the data. Tang et al. (2010) focus on the Chinese economy and describe a short-term effect on price and monetary variables as well as a long-term effect on output and investment variables. Farzanegan and Markwardt (2009) describe the effect within the Iranian economy-a net oil producing country.

Several studies identify asymmetric effects of oil price shocks. Mork (1989) discriminates upward and downward shocks in oil prices and shows an asymmetric response of macroeconomic variables. He concludes, on the data sample previously used by Hamilton (1983), that upward shocks are negatively related to GDP, whereas the impact of downward shocks is insignificant. Hamilton (1996) suggests a form of time asymmetry by claiming that most upward movements in oil are simply corrections of preceding downward shocks. Adjusting for this factor, he concluded that his earlier convictions (Hamilton 1983, 1985) could be supported by an asymmetric view of the data. In a later work, Hamilton (2003) concludes that oil price increases are in general more valuable for the explanation of macroeconomic variables than decreases, while their predictive content is significantly lower if they simply correct preceding oil price decreases.

The main bulk of research focuses on single OPEC countries and the US in particular, but some studies on developing economies and emerging markets, in particular, net oil exporters, have been published. Eltony and Al-Awadi (2001) provide empirical evidence on the importance of oil price shocks in explaining macroeconomic variables for Kuwait. El-Anashasy (2009) provides similar evidence for Venezuela and further differentiates between long- and short-run effects. Olomola and Adejumo (2006) analyze the impact of oil price changes on macroeconomic variables in Nigeria and caution against a Dutch disease trap for the economy.

The research most closely related to this paper combines insights from the previous literature, like the differentiation between long- and short-run effects and the presence of asymmetries, while assessing a sample of global economies. Jimenez-Rodriguez and Sanchez (2005) analyze a sample of seven OECD countries with Norway and the Euro area. As previous studies, they conclude that oil price increases have a larger impact on economic performance than oil price declines. Due to the multi-country sample, they are able to differentiate between net oil importing and exporting countries. While they identify significant impacts for oil importers, results for exporters are ambiguous. Berument and Ceylan (2010) provide research on a sample of Middle Eastern and North African countries. They show significant effects for some of the sample countries, while results for others remain insignificant. Similar results are presented by Ghalayini (2011) who focuses on G7 and OPEC countries.

Without further extending this list, it is clear that the effects of oil price changes can be identified on the single economy level. It is consensus that the oil-economic performance relationship is subject to structural changes over time, asymmetries and that effects materialize over several time periods so that short- and long-run effects differ. Most academic literature focuses on the explanation of macroeconomic variables of one or more domestic economies. In contrast to oil prices, this macroeconomic data is not available on the frequency and timing that would be desirable for an empirical analysis on short-run affects. Such low-frequency data is too aggregated to identify an immediate relationship between economic performance and oil price shocks. A key contribution of our paper is hence the additional use of financial market data, which is available in daily and hence much higher frequency than traditional macroeconomic data. The data from equity markets provides a more imminent and less diluted view on changes that might be caused by oil price shocks. To the best of our knowledge, the equity view has so far been neglected in the existing literature, and there has been no research project incorporating a global sample of net oil importing and exporting countries under the use of data in daily frequency.

This paper contributes to the existing literature by comparing major global economies and measure their sensitivity towards oil price changes. More specifically, we provide a global ranking of countries according to the severity of short- and long-run effects of oil price changes on their economic performance. The econometric analysis is based on an Error Correction Model (ECM). In this setup, we are able to distinguish between different time-periods over which oil price changes impact economic performance and therefore estimate the period over which long-run effects materialize. Further, the econometric model allows us to test for structural breaks in the oil-economic performance relationship and thus account for structural changes in the analyzed economies. For robustness, we also test for the presence of asymmetries in the analyzed relationships. The analysis is based on GDP as well as MSCI data. The additional use of equity indices does not only capture the investors' perspective but also provides support for the GDP results. Besides the more robust results, we provide evidence from more data prone methods, including recalibration after structural changes as well as asymmetries.

The paper is structured as follows. In Section 2 we explain the country and data sample and the econometric models used. Section 3 presents a view on the core findings and Section 4 gives concluding remarks as well as an outlook for future avenues of this line of research. The Appendix is reserved for a more detailed and technical description of the data and econometric methods used.

2. Data and Methodology

To capture major oil producers and consumers, we narrow the list of considered countries to those that are a member of the OECD and/or OPEC. This provides us with a list of 52 countries.

The core variables are the gross domestic product (GDP), foreign exchange rate in terms of local currency to the US$ (FX), and the country MSCI[2] index levels. Naturally, availability of data and the selection mechanism yield a high representation of EMEA and Americas. Additional data includes crude oil net imports and production. Production data is based on OPEC (2015) and available for 12 sample countries. Net import data is collected by the Energy Information Administration (EIA 2015) for 34 sample countries, which are not OPEC members.

[2] MSCI in our sense denotes the entire family of MSCI (Morgan Stanley Capital Index, leading Indicator for equity markets) indices as maintained by MSCI Inc. For our research we especially utilize the "MSCI World" as well as MSCI country indices.

Market data, if not stated otherwise, is collected from Bloomberg (2015) data services (see summary Table 1).

Variable	Range	Frequency	Countries
Net Imports	1982-2014	Quarterly	34
Production	1982-2014	Quarterly	12
GDP	1982-2014	Quarterly	51
MSCI	1982-2014	Daily	42
Oil Prices	1982-2014	Daily	-
FX	1982-2014	Daily	-

***Table 1**: Overview of core variables. Column "Range" depicts the maximum available time frame; data for some countries is available at a shorter horizon.*

Figure 1 shows the countries in our study. Grey indicates the availability of at least two, and black the availability of all core variables. Countries that are not represented in this study are colored white. Appendix A.1 gives the full list of the analyzed countries.

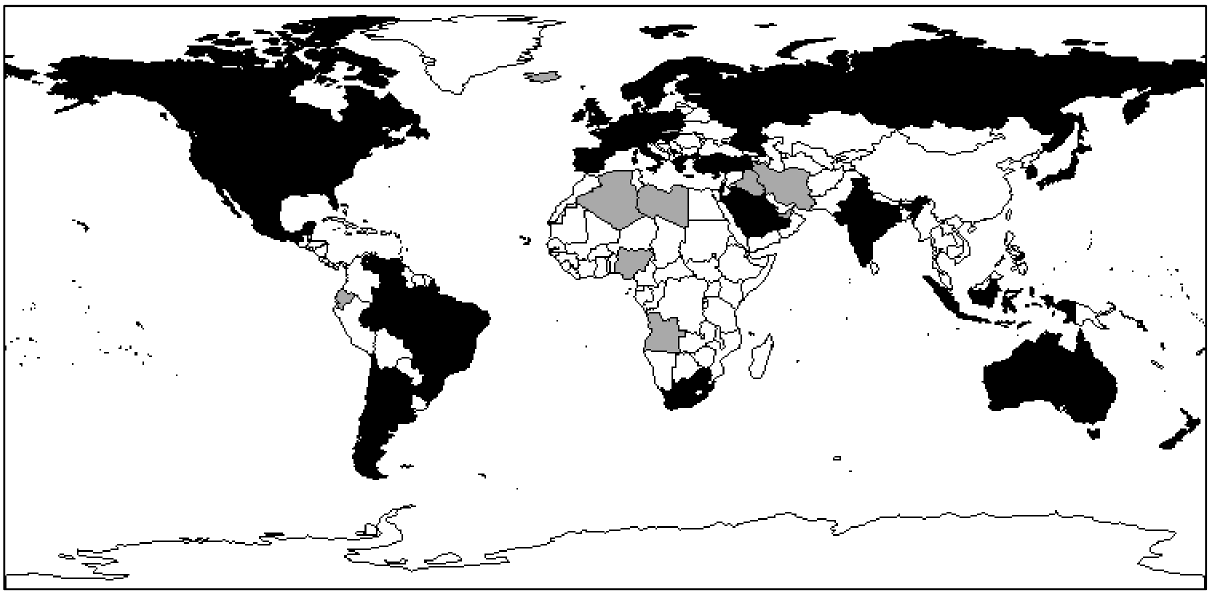

***Figure 1:** Countries and data availability for our study. Grey indicates the availability of at least two, and black the availability of all core variables.*

Existing empirical studies on the relationship between economic performance and global oil prices employ two broad modeling techniques: Co-integration analysis (e.g., Farzanegan and Markwardt 2009; Lardic and Mignon 2008; Al-mulali and Sab 2012), or first difference growth models (e.g., Berument et al. 2010; Jimenez-Rodriguez and Sanchez 2005; Jimenez-Rodriguez 2009; Larijani et al. 2013). This divide over the appropriate model specification arises due to prevailing non-stationarity of time series data. If the assumption of co-integration between the time series under consideration cannot be sustained, the long-run model is rejected in favor of the short-run growth model. This paper suggests an Error Correction Model (ECM) instead, which allows us to jointly estimate the short-run effect of oil price shocks and the long-run equilibrium relationship between economic performance and oil prices. If an equilibrium relationship is rejected, the model collapses into a growth model.

According to the Granger Representation Theorem (GRT), the relationship between two time series can be expressed as an ECM if these two series are co-integrated (Engle and Granger 1987). For the purpose of this paper the co-integration relationship is specified as:

$$y_{i,t} = \gamma_0 + \gamma_1 p_t + \gamma_2 e_t + u_t \qquad (1)$$

with $y_{i,t}$ being the i^{th} country's economic performance (GDP or MSCI) at time t, p_t is the oil price at time t, e_t is the exchange rate, γ_1 is the co-integrating vector, and u_t is the equilibrium error, that is the deviation from the equilibrium relationship at time t. Logarithms are used so that the coefficients estimated resemble elasticities.

The underlying assumption of Equation (1) is a time invariant linear long-run equilibrium relationship between economic performance and global oil prices. A necessary prerequisite for this assumption is that both time series integrate to the same order-commonly I(1). If $u_t \sim I(0)$ of Equation (1) the time series are said to be co-integrated.[3]

By exploitation of the condition $u_t \sim I(0)$ with co-integration, the deviation from the long-run equilibrium state captured in the error term can be incorporated into a growth model, which yields an ECM (Banerjee et al. 1998). In doing so, two additional information can be extracted: the short-run elasticity, which is the immediate effect of an oil price change on the country's economic performance, and the speed with which a country's GDP/MSCI returns to its equilibrium state (subscripts i are dropped for ease of presentation).

$$\Delta y_t = \beta_0 + \sum_{j=0}^{k} \beta_{1,j} \Delta p_{t-j} + \sum_{j=0}^{l} \beta_{2,j} \Delta e_{t-j} - \rho u_{t-1} + \varepsilon_t \qquad (2)$$

β_1 and β_2 capture short-run elasticities. The lag lengths k and l are decided by Schwarz Information Criterion (SIC). u_{t-1} is the last period's long-run equilibrium error from Equation (1). The coefficient ρ provides the speed of adjustment, i.e., the speed at which economic performance moves back to its equilibrium relationship after a change in oil prices or exchange rate. For the two-time series to be co-integrated: $\rho < 0$, that is, the speed of adjustment coefficient has to be significantly different from zero and negative. The long-run co-integrating

[3] This condition is tested with Augmented Dickey Fuller (ADF) tests with no constant (Dickey and Fuller 1979; Said and Dickey 1984). The lag length is chosen by SIC. If heteroscedasticity is detected in the residuals, Phillips-Perron (PP) is used instead (Phillips and Perron 1988). For robustness, Kwiatkowski-Phillips-Schmidt-Shin (KPSS) is used in addition (Kwiatkowski et al. 1992).

relationship is rejected if: $\rho = 0$, and Equation (2) collapses into a first difference growth model.[4]

Equation (2) can be transformed into a regression equation as specified below (with $\beta_3^* = \beta_4^* = \beta_5^* = 0$ in case of a rejection of the long-run relationship):[5]

$$\Delta y_t = \beta_0 + \sum_{j=0}^{k} \beta_{1,j} \Delta p_{t-j} + \sum_{j=0}^{l} \beta_{2,j} \Delta e_{t-j} + \beta_3^* y_{t-1} + \beta_4^* p_{t-1} + \beta_5^* e_{t-1} + \varepsilon_t \tag{3}$$

with $\beta_0 = -\rho\gamma_0$, $\rho = \beta_3^*$, $-\rho\gamma_1 = \beta_4^*$, and $-\rho\gamma_2 = \beta_5^*$ the original long-run equilibrium elasticity parameters from equation (1) can be recovered. The recovery is shown on the example of Brazil in the Appendix A.2.

A weakening or break in the relationship between oil prices and economic performance has empirically been related to non-linearity, that is, model misspecification, which arises due to an asymmetric sensitivity of economic performance to rising and falling oil prices (Mork 1989; Hamilton 1996, 2003; Hooker 1996). Generally, an economy's performance is found to react stronger to a positive than to a negative oil price shock. Following Mork (1989) and others (e.g., Mendoza and Vera 2010; Moshiri 2015; Lardic and Mignon 2008; Herreraa et al. 2015), we further differentiate between positive and negative oil prices shocks:

$$\Delta p_{i,t}^{+} = \begin{cases} \Delta p_{i,t} \text{ if } \Delta p_{i,t} > 0 \\ 0 \text{ otherwise} \end{cases} \qquad \Delta p_{i,t}^{-} = \begin{cases} \Delta p_{i,t} \text{ if } \Delta p_{i,t} < 0 \\ 0 \text{ otherwise} \end{cases} \tag{4}$$

The growth model (Equation (3) with $\beta_3^* = \beta_4^* = \beta_5^* = 0$) would hence yield coefficient estimates for $\beta_{1,j}^{+}$ and $\beta_{1,j}^{-}$, replacing $\beta_{1,j}$ in Equation (3). If a long-run relationship can be estimated, an asymmetric ECM is chosen by transformation of Equation (2):

$$\Delta y_t = \beta_0 + \sum_{j=0}^{k} \beta_{1,j} \Delta p_{t-j}^{+} + \sum_{j=0}^{k} \beta_{1,j} \Delta p_{t-j}^{-} + \sum_{j=0}^{l} \beta_{2,j} \Delta e_{t-j} - I_t \rho_p u_{t-1} - (1 - I_t) \rho_n u_{t-1} + \varepsilon_t \tag{5}$$

with I_t being the Heaviside indicator $I_t = 1$ if $u_{t-1} \geq \tau$ and $I_t = 0$ if $u_{t-1} < \tau$. If the past error in Equation (1) is bigger than the threshold τ, that is if y_t is above its long-run equilibrium $\hat{y}_t$, then adjustment is of rate ρ_p. If y_t is below its long-run equilibrium $\hat{y}_t$, adjustment is

[4] In this case the aggregated lagged impact can be interpreted as the long-run component.

[5] Since in the case of co-integration the t-statistics calculated do not follow the student t-distribution, Banerjee, Dolado and Mestre (1998), five per cent critical values are used.

of rate ρ_n. If $\rho_p = \rho_n$, adjustment is symmetric and Equation (5) is rejected in favor of Equation (2).

A weakening in the oil–economic performance relationship might be related not only to non-linearity arising from asymmetries, but also to a changing composition of a country's energy consumption, working of monetary policy and real wage rigidity (Loscos et al. 2011; Balke et al. 2002). Therefore, the analysis is augmented by tests for parameter instability. Parameter instability of the long-run parameter is of particular interest, since this would indicate regime shifts in the equilibrium relationship following from structural change.

Recursive as well as rolling coefficient estimation techniques are used in order to graphically assess changes in parameter estimates over the time period under consideration (Pollock 2003).[6] The locations of the break points are identified by rolling break point Chow tests.

3. Empirical Results

As set out in the previous section, we analyze the impact of oil price movements on the country's GDP and MSCI as dependent variables in an ECM model and thus provide an economic and an investment view. Regression equation (3) is estimated for both macroeconomic data using GDP as an indicator of economic performance, as well as financial data using the respective country's MSCI outperformance, over the worldwide MSCI benchmark, as a financial performance indicator. In a second step, tests for structural breaks are conducted. Where breaks have been identified regression equation (3) is re-estimated on a sub-sample starting after the last break point. In a third step, the regression equation is augmented to account for asymmetry, leading to regression equation (5).

The idea of the approach is to identify the elasticity of GDP/MSCI with respect to the oil price. The dynamic model specification in form of an ECM provides and easy distinction between long-run and short-run effects. The estimation yields firstly the long-run equilibrium elasticity estimator (percentage change of GDP/MSCI in respect to percentage change of the oil price) and secondly the short-run elasticity, which is the immediate effect of an oil price change on the country's GDP or equity market. Finally, the model provides an estimator for the speed of adjustment from the short to the long-run. To make this information easily accessible, we compute a half-life value for the adjustment process, i.e. the time until the economy experienced a 50 per cent adjustment to the long-run equilibrium. Prior to the analysis, all variables have been tested for non-stationarity. Those used for the regression results reported were found first difference stationary.

[6] In the former case the sample is gradually increased (starting point remains fixes while the ending point of the sample is moved forward) while in the latter case the sample size remains stable (starting point and ending point of the sample move forward through time in parallel).

3.1 Model Estimation

Tables 2 and 3 report estimation results using quarterly GDP as the dependent variable. On our sample of 52 countries, we calculate short-run and long-run elasticities with respect to the oil price. Additionally, we include exchange rates as control variable for other influences. The FX results will not be further interpreted. This way we estimate the out- or under-performance of the GDP in the wake of an oil price shock. The fitted models are then tested for structural breaks. Where breaks are identified, the break points are reported. Owing to the unique economic environment of OPEC countries, estimation results are reported separately in Table 2, while estimation results for OECD countries are reported in Table 3.

To provide easy access to the interpretation of the result, we will elaborate on the example of Saudi Arabia in Table 2, which has a high and very significant long-run elasticity of GDP with respect to oil. According to the long-run coefficient, a one per cent change in oil prices will lead to a 0.92 per cent accumulated increase in GDP. However, the long-run is estimated taking an infinite time horizon. The 3-year impact is estimated in the far right column which means that with a 1 per cent change in oil prices, Saudi Arabia’s GDP would grow by 0.66 per cent over a three-year period. While the long-run effect is positive, the contemporaneous or short-run effect is negative, but not significant. The half-life figure does give an indication of the speed with which GDP adjusts to an oil price shock. For Saudi Arabia, it takes 7 quarters until 50 per cent of the total long-run effect is reached. The last column indicates that there is a structural break in April 2011. The coefficients on the exchange rate for Saudi Arabia and the UAE are not reported due to the little variation in the exchange that is owed to its pack to the USD. For the four countries, we find the expected positive long-run impact. However, the short-run effect is of opposite sign but insignificant. The insignificant short-run effect might be related to the ability of large oil producers to buffer the price impact in the short-run with oil inventory management or managed extractions.

OECD economies in Table 3 are ranked according to the long-run elasticity of GDP with respect to the oil price. The selection of countries is based on a significant long-run (results for countries without a significant long-run coefficient are not reported). Of those countries with a significant (at the 10 per cent level) long-run coefficient, 11 show a positive long-run effect of an oil price shock. Seven economies, namely, France, Italy, Austria, Spain, Portugal, Greece, and Ireland (all of which are EU countries) show a negative long-run relationship between GDP and oil prices. This means an oil price slump does benefit the economic performance of these countries. We find strong positive long-term effects (1 per cent significance) for Russia, Brazil, Chile, Indonesia, Israel, and Mexico. All of these countries but Chile and Israel are main oil producers, while the two outliers adjoin to major oil producers which might result in spillover effects. For those countries showing a significant short-run effect, the direction of the effect coincides with the long-run effect and hence can be interpreted as the immediate adjustment towards the long-run. Figure 2 graphically summarizes estimation results regarding countries’ long-run elasticity of GDP with respect to oil prices.

	GDP full sample results (OPEC)							
	Oil		FX-Rate					
Country	**Long Run**	**Short Run**	**Long Run**	**Short Run**	**Half Life**	**3 Year Imp. Oil**	**3 Year Imp. FX**	**Break**
SaudiArabia	0.9163 ***	-0.0366	NA	NA	7	0.6567	NA	2011-4
UAE	0.9163 ***	-0.0453	NA	NA	7	0.6107	NA	2009-4
Algeria	0.7840 **	-0.0686	1.4266 **	1.1136 ***	7	0.5582	1.0563	2011-4
Kuwait	1.2997 *	-0.0007	4.9843	1.4008 *				2009-4

***Table 2**: ECM results on the impact of oil on GDP using all available data. The average R-Squared over all displayed ECMs is 24.81 per cent. 3 Year Imp. Oil is the accumulated impact of an oil shock on GDP after 3 years. *, ** and *** indicates significance at 10, 5 and 1 percent respectively.*

	GDP full sample results (excluding OPEC)							
	Oil		FX-Rate					
Country	**Long Run**	**Short Run**	**Long Run**	**Short Run**	**Half Life**	**3 Year Imp. Oil**	**3 Year Imp. FX**	**Break**
Russia	**0.2708** ***	**0.0213** ***	**0.1304** ***	**-0.0446** ***	**6**	**0.2051**	**0.1023**	**None**
Slovakia	0.3133 *	-0.0103	0.0170	-0.0501 *				2009-1
Brazil	**0.2436** ***	**0.0302** ***	**-0.0343**	**-0.0088**	**6**	**0.1814**	**-0.0265**	**None**
Chile	0.2930 ***	0.0153 *	-0.0736	-0.0552 **	10	0.1736	-0.0458	2010-2
Indonesia	0.5784 ***	0.0244	-0.2850 ***	-0.0381	19	0.1988	-0.1044	1999-1
Estonia	0.3552 **	0.0565 **	0.7449 **	0.0216	15	0.1504	0.3348	2008-4
Czech Republic	0.2093 *	0.0113 ***	0.0162	-0.0255 **				2009-1
Israel	**0.2883** ***	**0.0146** ***	**0.0591**	**0.0150**	**15**	**0.1231**	**0.0268**	**None**
Mexico	0.1683 ***	0.0081 **	0.1186 ***	-0.0186	13	0.0769	0.0574	2009-1
Canada	0.4043 **	0.0070 **	1.6757 **	-0.0055	97	0.0319	0.1426	2009-1
Switzer-land	0.3042 **	0.0036	0.3602	0.0184 ***				2008-4
France	-1.9353 **	0.0024	-2.7463	0.0026				2008-4
Italy	-0.2112 *	-0.0005	-0.5108	0.0056				2008-4
Austria	-0.8641 *	0.0045	-0.0907	-0.0006				2010-2
Spain	-1.1894 **	-0.0034	-2.0734	0.0132				2009-1
Portugal	-0.7818 ***	0.0018	1.0778	-0.0001				2009-1
Greece	**-0.7615** **	**-0.0165**	**-1.3187**	**0.0569**				**None**
Ireland	-1.3858 ***	0.0074	-0.5096	-0.0108				2008-2

***Table 3**: ECM results on the impact of oil on GDP using all available data. The average R-Squared over all displayed ECMs is 28.45 per cent. 3 Year Imp. Oil is the accumulated impact of an oil shock on GDP after 3 years. *, ** and *** indicates significance at 10, 5 and 1 percent respectively.*

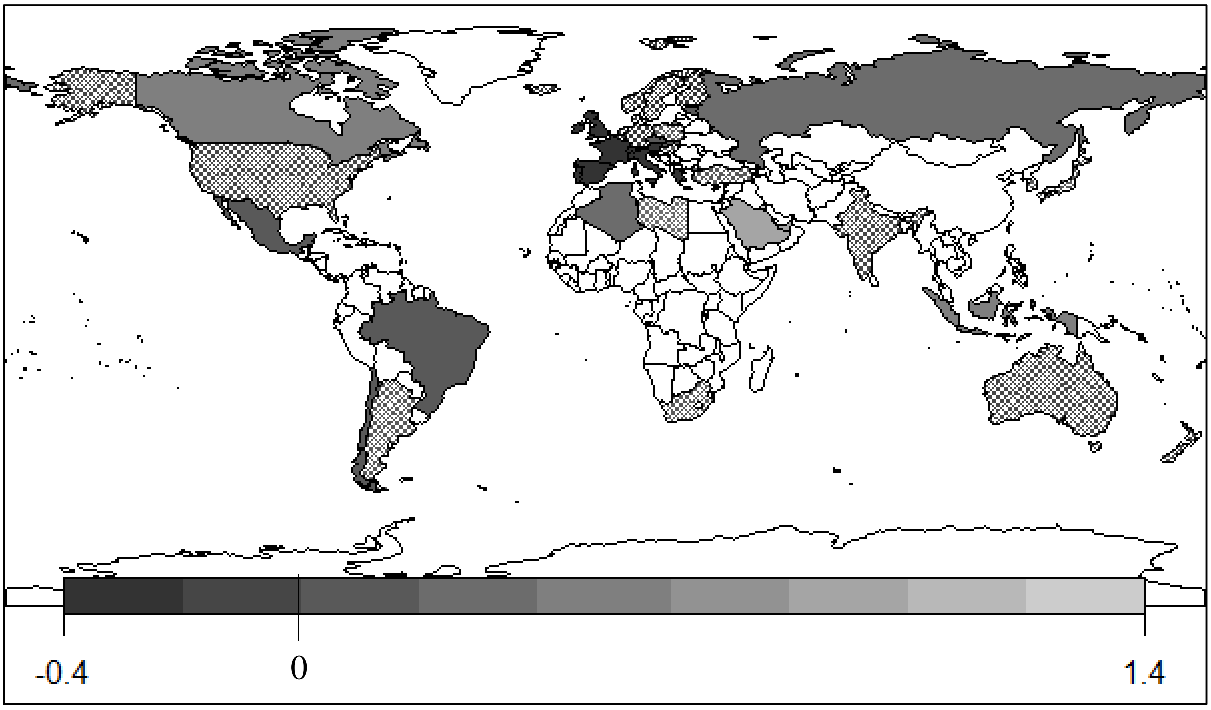

Figure 2*: Long-term effect on GDP. This figure depicts the long-term coefficient of oil on GDP. Solid coloring depicts significance greater than 10 per cent. The grey scaling describes the magnitude of the impact.*

In a second step, we repeat the estimation procedure using the MSCI and control for FX effects and global market changes. Since MSCI data is available in daily frequency, we gain a better representation of the recent past. On a sample of 38 countries, we fit the ECM with the corresponding MSCI country index as the dependent variable. Due to a lack of data availability, this analysis cannot be extended to OPEC countries.

Table 4 provides the estimation results ranked by the long-run elasticity. 10 countries show a positive long-run relationship between economic performance and oil prices. 14 show a negative relationship and the elasticity estimates for the remaining four countries are negative but insignificant (in italic). The latter four countries are included since the insignificance of the long-run elasticity can be related to structural breaks as shown in the following sub-section. Apart from Switzerland, the US, the UK and Estonia short-run coefficients-where significant-show the same sign than long-run coefficients. The switch in sign might indicate a country's ability to adapt to a changing oil price environment. For instance, countries with oil reserves that are difficult to be extracted might show this kind of effect. Figures 3 and 4 summarize the results graphically.

	MSCI full sample results (excluding OPEC)							
	Oil		FX-Rate					
Country	Long Run	Short Run	Long Run	Short Run	Half Life	3 Year Imp Oil	3 Year Imp FX	Break
Brazil	**0.7350 ****	**0.0153**	**-0.2600 ***	**-0.4595 *****	**308**	**0.6729**	**-0.2380**	**None**
Denmark	0.4590 ***	0.0186 ***	0.9252 ***	0.1599 ***	243	0.4390	0.8849	04.11.2008
Canada	0.4486 ***	0.0223 ***	0.9188 **	0.0908 ***	247	0.4278	0.8763	14.10.2008
Australia	0.1892 ***	0.0545 ***	0.2521 **	-0.0855 *	113	0.1890	0.2518	16.10.2008
Mexico	**0.7865 ****	**0.0004**	**0.1093**	**-0.7255 *****	**489**	**0.6199**	**0.0861**	**None**
Norway	0.2892 ***	0.0615 ***	0.3365	0.0632 *	189	0.2841	0.3305	28.04.2008
Sweden	**0.1535 ****	**-0.0043**	**1.1057 *****	**0.1585 *****	**151**	**0.1525**	**1.0986**	**23.03.2000**
Chile	**0.7845 ****	**0.0060**	**0.9979**	**-0.8055 *****	**779**	**0.4884**	**0.6213**	**None**
Switzerland	0.1872 **	-0.0173 ***	1.3613 ***	0.3846 ***	411	0.1577	1.1469	16.01.2015
United States	0.1012 *	-0.0191 ***	0.4043	0.3083 ***	283	0.0942	0.3766	01.07.2008
Czech Republic	-0.2288	*0.0464* ***	-1.0248	*0.0073*				*28.11.2000*
United Kingdom	**-0.0483 ****	**0.0105 ****	**0.6500 *****	**0.2301 *****	**116**	**-0.0482**	**0.6492**	**06.10.1998**
Belgium	-0.1682	*-0.0102*	0.9482 *	*0.2796* ***				*16.09.2008*
Ireland	-0.4673	*0.0131*	3.3445 *	*0.2328* ***				*06.11.2008*
Spain	-0.3178	*-0.0063*	-0.6631	*0.1575* ***				*08.11.2010*
France	**-0.1697 ****	**0.0047**	**0.5569 ****	**0.3246 *****	**185**	**-0.1671**	**0.5569**	**None**
Netherlands	**-0.0689 ****	**-0.0066**	**0.9945 *****	**0.4050 *****	**66**	**-0.0689**	**0.9945**	**None**
Estonia	-0.7193 ***	0.1046 ***	0.6443	0.0128	235	-0.6911	0.6191	16.07.2009
Finland	**-0.6418 *****	**-0.0095**	**0.3184**	**0.5115 *****	**209**	**-0.6258**	**0.3105**	**None**

***Table 4**: ECM results on the impact of oil on MSCI using all available data. The average R-Squared over all displayed ECMs is 38.84 %. 3 Year Imp is the accumulated impact of an oil shock on GDP after 3 years.*

Taking the United Kingdom as an example, a 1 per cent rise in the oil price leads to a -0.05 per cent loss in the country's MSCI over the following three years relative to the world MSCI. Therefore, a falling oil price leads to a relative outperformance of UK's equity market in comparison to the world equity market. The immediate or contemporaneous impact is opposite in sign. A 1 percent rise in oil prices leads to an immediate 0.01 percent gain in the country's MSCU. It takes 116 days until half of the long-run effect is reached.

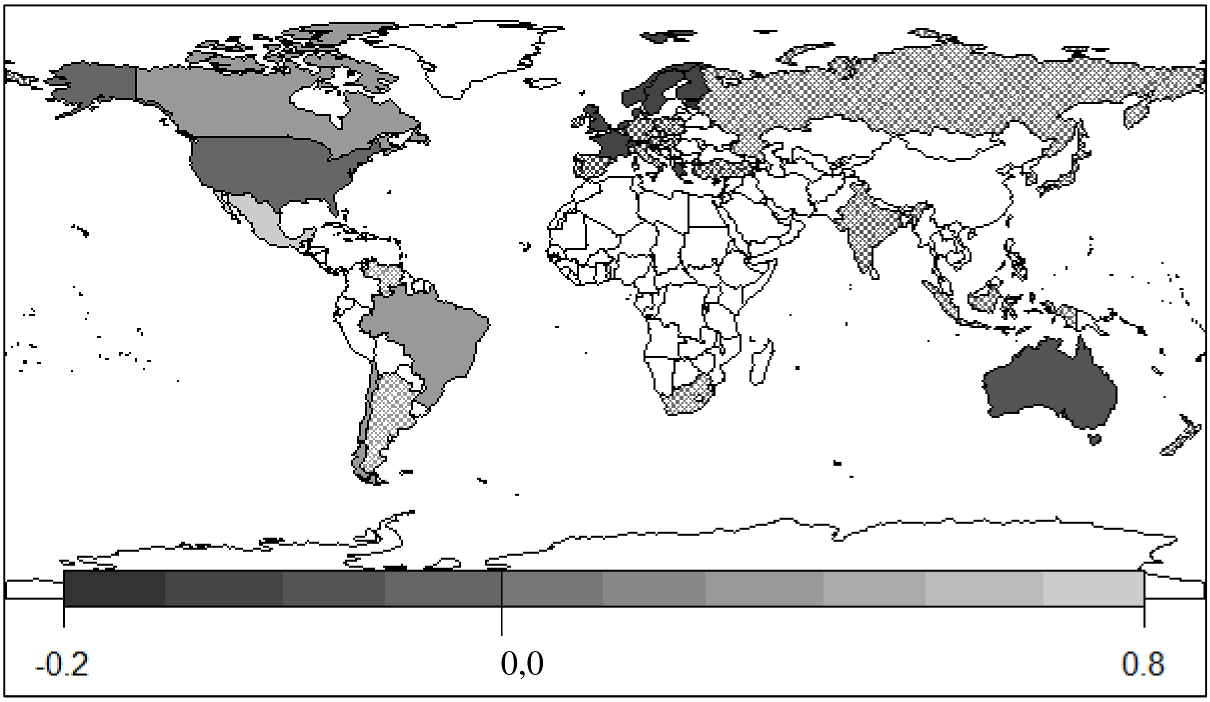

Figure 3: *Long-term effect on MSCI. This figure depicts the long-term coefficient of oil on MSCI. Solid coloring depicts significance greater than 10 per cent. The grey scaling describes the magnitude of the impact.*

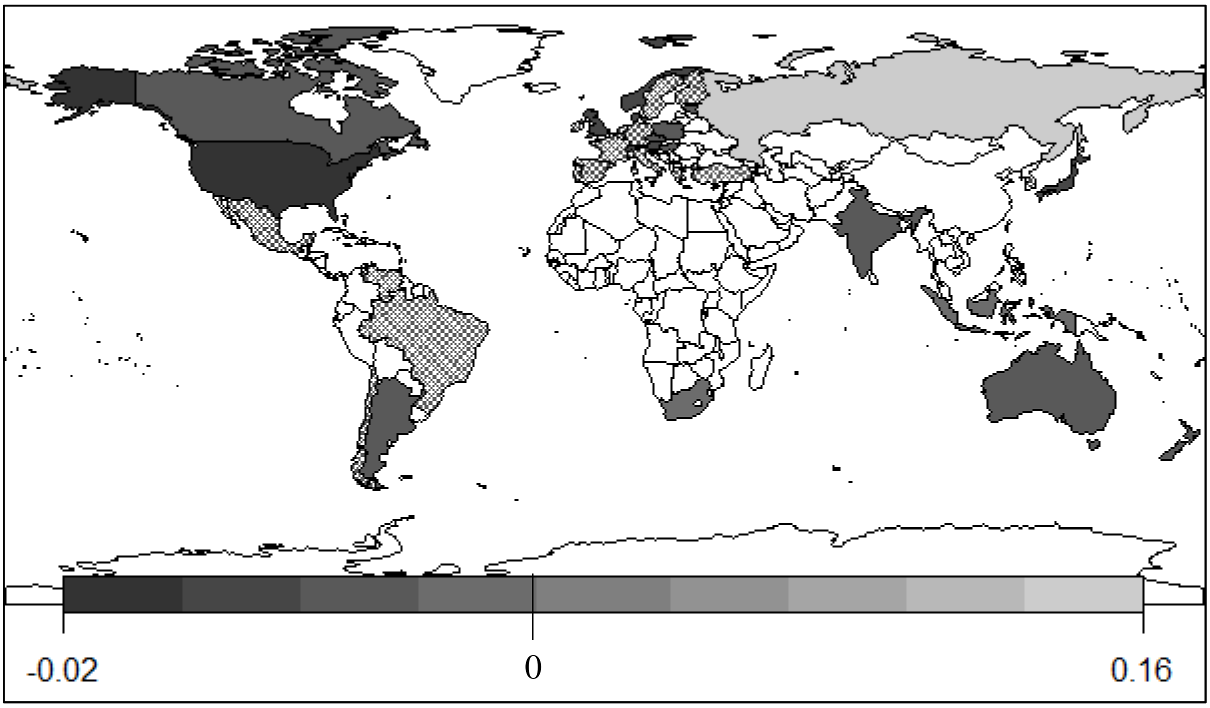

Figure 4: *Short-term effect on MSCI. This figure depicts the short-term coefficient of oil on MSCI. Solid coloring depicts significance greater than 10 per cent. The grey scaling describes the magnitude of the impact.*

Comparing the GDP with the MSCI results, we find that for the significant long-run effects six countries show the same results, namely, Brazil, Canada, Mexico, Chile, Switzerland, and France. The only exception is Estonia. Hence, where data availability allows for comparison, the results of both measures show that the MSCI elasticity is also a good indicator for the GDP. Extending the analysis to account for structural breaks or asymmetric impacts requires in most cases the use of daily data to ensure a large enough sample size to the break point for satisfyingly robust results. We, therefore, focus on the MSCI measure in the following sub-section.

3.2 Structural Breaks

Table 5 reports estimation results for the sub-samples starting from the last identified break point for the MSCI data. For most countries, structural breaks appear around the financial crisis 2008/09. For ease of comparison, the order of countries in Table 5 resembles Table 4.

	MSCI results after last structural break							
		Oil		FX-Rate				
Country	Break	Long Run	Short Run	Long Run	Short Run	Half Life	3Year Imp Oil	3Year Imp FX
__Brazil__	__None__	__0.7350__ **	__0.0153__	__-0.2600__ *	__-0.4595__ ***	__308__	__0.6729__	__-0.2380__
Denmark	04.11.2008	-0.0175	0.0687 ***	1.4013 ***	0.3684 ***			
Canada	14.10.2008	-0.2699	0.0154	-0.5920	0.2710 ***			
Australia	16.10.2008	-0.2124 **	0.0933 ***	-0.1124	0.0791	38	-0.2124	-0.1124
__Mexico__	__None__	__0.7865__ **	__0.0004__	__0.1093__	__-0.7255__ ***	__489__	__0.6199__	__0.0861__
Norway	28.04.2008	-0.0792	0.1430 ***	-0.6125 ***	-0.1230 **			
	MSCI results after last structural break							
		Oil		FX-Rate				
__Sweden__	__23.03.2000__	__0.2130__ **	__-0.0066__	__0.7134__ *	__0.0609__	__106__	__0.2129__	__0.7130__
__Chile__	__None__	__0.7845__ **	__0.0060__	__0.9979__	__-0.8055__ ***	__779__	__0.4884__	__0.6213__
Switzerland^	16.01.2015							
US	01.07.2008	0.0685	-0.0411 ***	0.3670	0.3791 ***			
Czech Rep.	_28.11.2000_	_-1.3376_ ***	0.0766 ***	_-3.2588_ **	0.0189	327	_-1.2096_	_-2.9471_
__UK__	__06.10.1998__	__-0.0526__ ***	__0.0120__	__0.4075__ ***	__0.2433__ ***	__43__	__-0.0526__	__0.4075__
Belgium	_16.09.2008_	_-0.1820_ ***	_0.0529_ ***	_1.1363_ ***	_0.2324_ ***	_42_	_-0.1820_	_1.1363_
Ireland	_06.11.2008_	_-0.2897_ *	_0.0443_	_0.3927_	_0.4220_ ***			
Spain	_08.11.2010_	_-0.6397_ **	_-0.0162_	_-2.1593_ *	_-0.0631_	_66_	_-0.6397_	_-2.1593_
__France__	__None__	__-0.1697__ **	__0.0047__	__0.5569__ **	__0.3246__ ***	__185__	__-0.1671__	__0.5569__
__Netherlands__	__None__	__-0.0689__ **	__-0.0066__	__0.9945__ ***	__0.4050__ ***	__66__	__-0.0689__	__0.9945__
Estonia	16.07.2009	-0.3296	0.1279 ***	0.5732	0.1269			
__Finland__	__None__	__-0.6418__ ***	__-0.0095__	__0.3184__	__0.5115__ ***	__209__	__-0.6258__	__0.3105__

***Table 5**: ECM results on the impact of oil on MSCI after the last structural break. The average R-Squared over all displayed ECMs is 45.25 %. 3YearImp is the accumulated impact of an oil shock on GDP after 3 years. ^Insufficient sample size for estimation.*

For six countries, namely, Brazil, Mexico, Chile, France, Netherlands, and Finland, we find no structural breaks. For two countries, namely, Sweden and the United Kingdom, the direction and approximate size of the long-run effect are identical with full sample estimation and stays significant. However, for both countries the speed of adjustment coefficient increases which means after the break the transmission of oil price shocks to economic performance is quicker than previously. For four countries, Czech Republic, Belgium, Ireland and Spain, we now find significant and negative results in the long-run. For Australia, the short- and long-run effects are opposite in sign, which indicates that the countries underwent structural changes which led to an inverse relationship between economic performance and oil prices past 2008.

By using the MSCI, eight out of 15 countries in our sample show the same significant impact direction over the full sample and after the last structural break. For five countries, the long-run elasticity estimate turns insignificant, while the sign switches for one country. For those eight countries with no structural break or consistent estimates across full and sub-sample, estimated elasticities are robust. For the remaining countries, structural changes prohibit a conclusive analysis.

3.3 Asymmetries

We turn to testing for directional asymmetries in the relationship between oil prices and MSCI, again utilizing the advantages of higher frequency data. Results for the asymmetric ECMs taking MSCI as the dependent variable are reported in Table 6. Short-run elasticities for positive and negative oil price changes are estimated separately and reported in the left half of the table. Two speed of adjustment coefficients are reported in form of percentage adjustment per one period. It is differentiated between positive adjustment (+Adj.), which is the speed with which MSCI adjusts downward to its long-run value and negative adjustment (-Adj.), which is the speed with which MSCI adjust upward towards its long-run value. Those speed of adjustment coefficients found significant are in bold. If the adjustment coefficients differ significantly, asymmetric effects are found.

In line with previous studies, the negative adjustment coefficient (-Adj.) is significant and relatively large for nine out of 19 countries while the positive adjustment coefficient (+Adj.) is insignificant. This finding suggests asymmetric adjustments and a faster adjustment to positive oil price shocks than to negative oil price shocks. Only for Brazil, the positive adjustment coefficient is significantly larger than the negative coefficient, which suggests that the Brazilian MSCI reacts stronger to negative than to positive oil price changes. For the remaining nine countries, no significant asymmetries are identified.

Regarding instantaneous or short-run effects, where found significant, the signs of the coefficients for the effect of negative and positive oil price changes are identical, which is expected. For several countries asymmetries are identified with a stronger effect of negative price changes than positive price changes; namely for Brazil, Canada, the US, Czech Republic, UK, Belgium, Ireland, Spain, France, Netherlands and Finland. Only for Chile and Switzerland are effects of positive oil price changes larger than effects of negative oil price changes. This means that negative oil price shocks have an immediate and temporary impact on MSCI, while positive shocks have a more permanent effect.

	MSCI results with asymmetric ECM												
	Oil Short-run						FX-Rate Short-run						
Country	**Positive**		**t-val**	**Negative**		**t-val**	**Coef.**		**t-val**	**+Adj in %**	**t**	**-Adj in %**	**t**
Brazil	0.0470	**	2.05	0.0742	***	3.23	-0.6551	***	-27.2	**0.46**	**-2.70**	0.04	-0.25
Denmark	0.0234	***	2.61	0.0284	***	3.33	-0.0181		-0.97	0.06	-1.28	0.05	0.98
Canada	0.0093		1.16	0.0283	***	3.74	-0.4792	***	-10.0	0.02	0.24	0.02	-0.55
Australia	0.0269	***	3.33	0.0267	***	2.47	-0.2429	***	-15.8	0.07	-0.95	**0.07**	**-1.87**
Mexico	0.0207		1.53	-0.0004		-0.28	-0.9662	***	-43.1	0.01	0.11	**0.32**	**-4.08**
Norway	0.0654	***	5.60	0.0766	***	6.91	0.0000		0.00	0.04	-0.49	**0.09**	**-1.65**
Sweden	-0.0036		-0.32	0.0049		0.45	-0.2233	***	-9.92	0.04	0.81	0.02	-0.51
Chile	0.0253	**	2.54	0.0024		0.25	-1.0981	***	-40.2	0.06	-0.88	**0.11**	**-1.81**
Switzerland	-0.0215	**	-2.52	0.0034		0.42	0.2914	***	18.1	0.06	-1.41	0.03	0.70
United States	-0.0005		-0.03	0.0476	***	2.99	-0.1145	***	-3.66	0.20	1.04	**0.50**	**-2.34**
Czech Repub.	0.0379	**	2.40	0.1005	***	6.50	-0.1914	***	-7.37	0.07	-0.43	0.02	0.10
UK	0.0065		0.76	0.0263	***	3.25	-0.0315	*	-1.66	0.05	-0.93	0.04	-0.91
Belgium	0.0135		0.77	0.0618	***	3.58	-0.0676	**	-1.98	0.05	-0.33	0.02	-1.44
Ireland	0.0413	*	1.93	0.0846	***	4.03	-0.1260	***	-3.02	0.10	-1.01	0.12	-0.96
Spain	0.0206		1.06	0.0785	***	4.10	-0.2590	***	-6.81	0.13	-0.57	**0.41**	**-1.82**
France	0.0232		1.27	0.0994	***	5.51	-0.1142	***	-3.18	0.04	-0.19	**0.43**	**-1.96**
Netherlands	0.0104		0.58	0.0833	***	4.74	-0.0004		-0.01	0.13	0.58	**0.50**	**-2.34**
Estonia	0.1164	***	4.94	0.1405	***	6.10	-0.1561	***	-3.73	0.02	0.15	0.23	-1.45
Finland	0.0240		0.86	0.0932	***	3.39	0.0188		0.34	0.09	-0.52	**0.44**	**-1.77**

Table 6*: ECM results on the impact of oil on MSCI using all available data. Significant adjustment terms in bold (at 10% significance). Adjustments in percentage change per time period (day). +Adj. in % indicates the speed with which MSCI adjusts downwards toward its equilibrium and –Adj. in % indicates the speed with which MSCI adjusts upward towards its equilibrium. If +Adj. significant and greater than –Adj., MSCI is relatively sticky upward and vice versa.*

The asymmetric ECM is a restricted version of the ECM described in Equation (3). The long-run effects are estimated in the unrestricted ECM, while the restricted ECM described in Equation (5), measures differences in the speed with which the system moves towards the previously estimated long-run value. Results suggest that the MSCI of the majority of countries analyzed in this paper adjusts quicker to an undervaluation (upward adjustment) than to an overvaluation (downward adjustment).

4. Conclusion

The role of crude oil as the major benchmark commodity has long motivated several lines of research. The recent period of strong market movements has led to a renaissance of both academic as well as professional interest in the behavior and impact of oil price changes on economic performance. This paper contributes to the debate by presenting empirical evidence on the impact of oil price changes on a global macroeconomic level. More specifically, we provide estimates for the severity of short- and long-run effects of oil prices changes on the economic performance of several OECD and OPEC countries and the speed with which these changes materialize. Further, we test for structural breaks in the relationship and investigate the presence for asymmetries in the relationship between oil prices and economic performance.

Besides the classical GDP measure, we focus on equity markets, as measured by the global MSCI index family. For the latter, we focus on relative outperformance over a worldwide benchmark that can be attributed to oil price shocks. This captures the reaction of a market that is able to process relevant information close to imminently. We further find that using MSCI data is a good approximation for GDP changes towards the long-run relationship between oil prices and MSCI.

By using ECMs, we are able to rank countries regarding the sensitivity of MSCI to changes in the oil price. Especially the relative MSCI of a country proofs to be a fruitful approach, as daily data make, in almost all cases, estimation after a structural break possible and more robust. Where data availability allows for comparison, the results of both measures are aligned. Asymmetric ECMs provide a more disaggregated view on the speed of adjustment term by differentiating between and upward and downward adjustment.

According to our MSCI analysis, the strongest positive long-run effects over a three-year period are found for Brazil, Denmark, Canada, Mexico, Norway, and Chile. The strongest negative long-run effects over the same period are found for France, Estonia, and Finland. After accounting for structural breaks, the strongest positive long-run effects are found in Brazil, Mexico, Sweden, and Chile. Respectively, the strongest negative long-run effects are found for Australia, Czech Republic, Belgium, Ireland, Spain, France, and Finland. Therefore, we were able to identify these countries to out-/ under-perform the equity market in comparison to the global benchmark. The results are similar when measuring the effects on GDP. For those countries that are significant at a 5% level or higher, half of the adjustment process from short-term to long-term is less than six months, with the exception of Finland, which shows a slightly longer adjustment period. The analysis under directional asymmetries provides evidence for a tendency of MSCI to be rigid downward but flexible upward for most countries.

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