



# A time-varying copula approach to oil and stock market dependence: The case of transition economies



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## ABSTRACT

We employ the time-varying copula approach to investigate the conditional dependence between the Brent crude oil price and stock markets in the Central and Eastern European (CEE) transition economies. Our results show evidence of a positive dependence between the oil and the stock markets of the six CEE countries, which is indicative of a contagion between those markets, regardless of the changes in the oil price or the CEE stock index. Moreover, the dependence patterns in both the center and left tails of the return distributions change over time, particularly during the heart of the financial crisis, and are best described by the Survival Gumbel copulas. The empirical evidence also suggests that the lower tail dependence is much stronger than that of the upper tail, highlighting the importance of contagion during severe contractionary business cycles. Among the sample markets, Poland is shown to be particularly sensitive in this regard, while Hungary and Slovenia are the least sensitive.

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## 1. Introduction

There is a strong presumption in the economic and financial literature that oil prices impact stock markets negatively, mostly due to their connection with inflation and precautionary oil demand (Barsky and Kilian, 2004; Ciner, 2001; Hooker, 1996; Papapetrou, 2001; Sadorsky, 1999). Studies have been carried out on the oil price–stock market nexus for the major industrial countries, Latin American countries, African countries, emerging market economies and oil producing countries but the literature has yielded mixed results. This literature shows no consensus that there is a defined relationship between oil prices and stock markets across different countries. For example, Apergis and Miller (2009) examine whether structural oil–market shocks have an impact on stock prices in eight developed countries and conclude that developed stock markets do not react significantly to oil price changes. In contrast, Park and Ratti (2008) find that oil price shocks have a statistically significant impact on real stock returns in the U.S. and thirteen European countries. They however show little evidence of asymmetric effects on

real stock returns for oil importing European countries of positive and negative shocks of the oil price. Nandha and Faff (2008) provide evidence that the rise in the price of oil has a negative impact on all industries but not the oil and gas industries. Kilian and Park (2009) find that the response of stock returns to oil prices may differ depending on the cause of the oil price shock.<sup>1</sup>

The literature, however, has not produced clear evidence on the oil–equity relationship in Central and Eastern European (CEE) countries, which are also different among themselves. The FTSE and MSCI groups recognize the Czech Republic, Hungary and Poland as advanced emerging markets, while the others are just emerging markets. Still, the CEE economies are net oil importers, vulnerable to oil supply disruptions, higher inflation, and some like Hungary have excessive price regulations imposed by their governments (Mohanty et al., 2010). They also differ in terms of indigenous primary sources of energy, size of GDP, GDP per capita, shares of industry

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<sup>1</sup> Several other studies address the relationship between oil prices and stock returns at the sector level (e.g., Aroui and Nguyen, 2010; Boyer and Filion, 2007; El-Sharif et al., 2005; Hammoudeh et al., 2010; Nandha and Brooks, 2009; Sadorsky, 2001). Their results indicate that the reaction of sector returns to changes in oil prices differs sensitively across sectors and that the presence of the oil assets in a portfolio of sector stocks permits to improve the portfolio's risk–return characteristics.

and agriculture in GDP, public debt, current account balance, and compensation per employee, among others (Havlik, 2012). Therefore, understanding the oil–stock market relationship for these transitional economies is important for investors and policy makers of those countries because of differences in relative contributions of oil to their energy consumption, oil intensity of their economic sectors, and composition of their economic structure.

The CEE countries have different relative energy dependence on oil, coal, natural gas and nuclear energy.<sup>2</sup> When it comes to oil consumption in these countries as a whole, more than 60% of oil is used in the transportation sectors, 10% in the industrial sector (steel, iron, aluminum etc.), and 16% in non-energy use sectors (Hugyecz, 2011; IEA, 2010). This suggests that oil affects most of the economic sectors of these countries, and that the behavior of their economic players such as households and business accounts for most of oil consumption. The oil–macroeconomy relationship underscores the importance of the level of economic activity in determining oil consumption. This also highlights the strong dependency of many companies on the quantity and price of oil and the relationship between oil prices and stock prices during bull and bear markets. The recent literature has shown that energy efficiency in the CEE economies has stalled since the 2007/2009 global financial crisis (IEA, 2010). This study will focus on the oil–stock market relationship for six major transition markets in the CEE region, namely Bulgaria, Czech Republic, Hungary, Poland, Romania, and Slovenia.

Under normal economic conditions, changes in oil prices can affect the CEE's companies from both the supply and the demand sides. From the supply side, surges in oil prices increase the cost of production, thereby affecting the profitability of those companies. From the demand side, increases in the cost of oil decrease consumers' discretionary expenditures which in turn reflect negatively on the profitability of the companies. This applies to Romania which produces some oil, as well as to Slovenia which basically produces no oil. The fact that the CEE economies are net importers (see, Fig. 2) implies that they are more vulnerable to oil supply distribution than oil exporters, which increases their sensitivity to oil price changes. Moreover, while some of these economies depend on coal or natural gas as a second major energy source to satisfy their industrial energy demand, they all depend to a varying degree on imported oil as the major source of the transportation or surface fuel which again highlights their oil susceptibility. As indicated earlier, more than 60% of oil consumption in these CEE countries is used in the transportation sector, while only 15% is used in the industrial sector. Having said all that, the dependence structure between oil and CEE stock returns can change under extreme conditions in the tail distributions because it can be affected by other factors including strong herding, differential market power and excessive price regulations imposed by governments.

The objectives of this study are: i) to examine the time-varying dependence between crude oil prices and stock returns in the six CEE transition countries; ii) to discern the strength of relative oil–stock market interdependence during bullish and bearish market phases in these countries, which is marked by the most recent financial crisis; and iii) to discuss the implications of the empirical results on the future development of stock markets in these six CEE countries, conditionally on the degree of their dependence on crude oil as well as on oil price movements.

Our article contributes to the related literature in several important aspects. We first make use of a time-varying copula (TVC) approach to investigate the dependence structure between oil and stock market returns through time. Indeed, not allowing for time-varying parameters in the dependence distribution generates a bias toward evidence of tail dependence. Similarly, considering only tail dependence may falsely lead to evidence of asymmetric relation between the returns. Empirically, return series are modeled by GARCH-type processes with suitable marginal distributions, and appropriate copula functions are then fitted to filtered return series in order to gauge their dynamic interdependence. By doing so, it is possible to capture the potential nonlinearities in the oil–stock market relationships as well as some well-known empirical stylized facts of their return distributions such as volatility persistence, fat tail behavior and asymmetric impacts of return innovations on volatility (Arouri et al., 2011; Regnier, 2007; Sadosky, 2006), while avoiding the drawbacks of linear measures of interdependence such as Pearson correlation (Jondeau and Rockinger, 2006). We are also able to examine both the degree and nature of return dependence at extreme levels, i.e., the possibility of joint extreme variations in the dynamics of oil and stock returns. Last but not least, the use of a more recent dataset, spanning the period from December 1, 2005 to August 20, 2012, enables us to account for several episodes of important fluctuations in oil and stock prices, especially over the 2007–2009 global financial crisis where extreme comovements are expected.

To the best of our knowledge, copulas have been previously used in German and Kharoubi (2008), Zohrabyan (2008), and Nguyen and Bhatti (2012) to examine the oil–stock market interactions.<sup>3</sup> German and Kharoubi (2008) analyze the diversification effect of including crude oil futures contracts into a portfolio of stocks, while accounting for time-to maturity for the futures contract. They use copula functions to examine the benefits of accounting for the “maturity effect” on portfolio diversification and find that distance maturity has a more pronounced negative correlation between the West Texas Intermediate (WTI) futures prices and the S&P 500 index, regardless of changes in the oil price. Zohrabyan (2008) employs copula functions in examining the dependence between oil prices and stock returns for three CEE countries (Poland, Czech Republic and Hungary), among other developed and developing countries. His final conclusion is that copula results are sensitive to different oil price scenarios generally, and before and after the establishment of the euro zone. Nguyen and Bhatti (2012) focus on the relationship between oil prices and stock markets in China and Vietnam which is an oil producer. The authors observe the presence of left tail dependency between oil prices and the Vietnamese stock market, but no such dependence for the Chinese market exists.

None of the above-mentioned studies use a TVC approach and allow for the choice of appropriate copulas among the most commonly-used copula families. However, the study by Wen et al. (2012) is most related to ours as it uses time-varying copulas to investigate whether contagion exists between oil and stock markets (WTI crude oil price, the S&P 500 index, and Chinese stock market indices), but their focus is more on the downside dependence patterns. Their results show significantly increasing dependence between the WTI oil and stock markets after the failure of Lehman Brothers, supporting the presence of contagion between these markets, but with weaker contagion for China than the United States.<sup>4</sup>

<sup>2</sup> The contributions of the primary sources of energy to total energy consumption differ from one CEE country to another during the period 2006–2010. In the Czech Republic, coal dominates energy consumption followed by crude oil (Hugyecz, 2011). Natural gas followed by crude oil dominates the consumption in Hungary. In Poland, coal stands out first and far, followed by a long distance by oil, somewhat similar to the Czech Republic. In Romania, similar to Hungary, natural gas comes first by a big shot, followed by crude oil and then coal. Bulgaria is also similar to the Czech Republic because coal dominates energy consumption followed by oil and natural gas. This country relies on nuclear energy for about 19% of its primary energy consumption.

<sup>3</sup> Copula models have also been recently used to examine the comovement of crude oil markets (Reboredo, 2011) as well as the conditional dependence structure between oil prices and exchange rates (Aloui et al., 2013; Wu et al., 2012).

<sup>4</sup> In a related study, Wei (2011) applies copula and goodness-of-fit (gof) tests to estimate the VaR and expected shortfall (ES) for 12,000 bivariate portfolios of stocks, commodities and FX futures. The analysis of three state-of-the-art approaches for testing a copula-model's goodness-of-fit showed that none of the tests were able to identify the optimal parametric form unequivocally. See, for instance, Zhang and Guégan (2008), and Fomby et al. (2012) for more discussions regarding other applications of time-varying copulas.

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