Addressing COP21 using a stock and oil market integration index

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\begin{abstract}
COP21 implementation should lead to a decline in the future demand for fossil fuels. One key implication for investors is how to manage this risk. We construct a monthly stock and oil market integration index and demonstrate that oil investors can offset adverse oil price risk by holding diversified global stock portfolios. The portfolios are formed from eight different combinations of developed and emerging stock markets. We show that measuring the degree of stock-oil market integration is critical to managing the time-varying degrees of integration. Under normal market conditions markets are segmented and this yields the opportunity for oil investors to diversify energy price risk through the purchase of stocks. The optimal oil-stock diversified portfolio provides risk-adjusted positive benefits to investors, with portfolio weights changing over time as COP21 implementation proceeds.
\end{abstract}

1. Introduction

One key impact arising from COP21,\textsuperscript{1} which forms part of recent sustainable global energy policy, is the expected and ongoing decline in the future demand for fossil fuels such as coal, oil and gas (Vandyck et al., 2016; Panagiotis et al., 2017). These outcomes link with broader public policy concerns\textsuperscript{2} over the impacts of climate change, which The Institute for Sustainability Leadership (2015) stresses, are basically unhedgeable.

In this paper, we address the financial market implications of COP21 implementation, by constructing a stock-oil integration index to show how oil investors can in fact diversify and then offset, or hedge, the demand related oil price risks that will arise from COP21.\textsuperscript{3} Central to these risk management strategies is the measurement of the

\begin{itemize}
\item \textsuperscript{1} COP21 refers to the agreement from the 2015 United Nations Climate Change Conference in Paris. The key result was an agreement to set a goal of limiting global warming to less than 2°C (degrees Celsius) compared to pre-industrial levels. The agreement calls for zero net anthropogenic greenhouse gas emissions to be reached during the second half of the 21st century.
\item \textsuperscript{2} In this context, Jefferson (2015) highlights that the world in the 21st century faces tremendous energy challenges that mainly arise from the demand side due to increasing population growth. Other recent measures include IMO 2020. The International Maritime Organization has set a global limit for sulphur in fuel oil used on board ships of 0.50% m/m (mass by mass) from 1 January 2020. This will significantly reduce the amount of sulphur oxide emanating from ships and should have major health and environmental benefits for the world, particularly for populations living close to ports and coasts (see http://www.imo.org/en/Pages/Default.aspx).
\item \textsuperscript{3} Consequently, this study adds to a developing literature that includes economic modelling of the broader macroeconomic impacts of COP21 implementation, including Keho (2016), Malova and van der Ploeg (2017) and Murphy and McDonnell (2017).
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statistical relationship between oil and financial assets. We show that investors that consider these relationships receive positive economic benefits since they can outperform naive trading strategies. These findings add to the understanding of the two-way relation between oil and stock market prices, which is also vital for regulatory and macroeconomic policy, both at a country and global level (Bernanke, 2016).

Financial assets may be combined with energy assets into portfolios along with developed and emerging country stock markets. Recent empirical studies on these portfolios have highlighted their time-varying correlation relationships, often with risk spill-overs between specific stock and energy markets. The focus of many of these studies tends to be on the impact of energy prices on developed country stock markets, which have historically been oil importers and those emerging markets, which tend to be oil exporters, such as those in the MENA region4 (e.g. Mensi et al., 2015; Demirer et al., 2015; Tsai, 2015; Kyrtsou et al., 2016; Balcilar et al., 2017). However, rather than investigate the stock markets of specific countries, we investigate impacts on region wide and global portfolios.

In constructing the oil-stock integration index, this study builds upon existing portfolio theory applied to international financial markets (e.g. Solnik, 1977; Stulz, 1981) and extends several recent applications to currency markets (e.g. Boubaki and Guillamina, 2011 amongst others) and regional stock markets (e.g. Guesmi and Teulon, 2014; Guesmi et al., 2014, amongst others). Importantly, theory shows that by holding uncorrelated financial assets in an international portfolio, from markets that may be isolated by geography, regulation or function, the risk of one stock or asset market can be used to offset the risk of the other. In the case of stock markets, combining portfolios across industries and other markets with varying degrees of liquidity and market access, allows an investor to eventually form diversified portfolios that minimise risk and transactions costs, while maximising expected return. This approach is critical for investors that wish to either hedge or diversify the risk associated with changing demand for financial assets, whose value is based on the price of fossil fuels.

Globalisation, the removal of capital controls and financial market regulatory convergence over the past two to three decades has tended to remove those barriers that once prevented investors undertaking various cross-border transactions. These changes have effectively expanded the range of possible investment opportunities available to investors beyond simply domestic ones. Consequently, in the spirit of many of these international studies, where the focus is on the inclusion of emerging stock markets, such as Bekaert and Harvey (1995, 1997, 2000), Gérard et al. (2003), Chi et al. (2006) and Jeon et al. (2006), we include emerging markets as well as various combinations of developed markets in our portfolio analysis.

Because of these changes, financial markets have become both more efficient and integrated. Integration measures the degree that price changes in one market affect all markets. An extensive recent literature (see for example, Sadorsky (2014), Khalifaoui et al. (2015), Mensi et al. (2015), Kyrtsou et al. (2016), Batten et al. (2017, henceforth simply BKSW, 2017)) in fact shows that these relationships vary over time as local market, or idiosyncratic factors (such as a change in government), that may limit system-wide impacts, are overridden by global factors. As the recent Global Financial Crisis (GFC) of 2007–2008 has shown, some shocks affect all markets, irrespective of location, although the impacts measured in terms of scale and scope may differ.5

We contribute to the far-ranging debate on the impacts of COP21 by showing how the impact of declining energy demand influences financial assets. Since these impacts can be measured, they can also subsequently be hedged, using existing derivative financial products, such as options and futures amongst others. Our approach follows an existing asset-pricing literature that determines the degree of integration between energy and key stock markets, measured as portfolios and then to use these statistical relationships to form stock-energy market portfolios under different conditions of integration and segmentation. Segmentation refers to the opposite state of integration, when the price effects in one asset market have no effect on the other.

But exactly how can investors do this? We begin by providing a clear understanding of the dynamic relationship between a key energy asset, West Texas Intermediate (WTI) and stock portfolios from various stock markets.6 We show that under normal market conditions, when markets are segmented, there is the opportunity for oil investors to diversify the additional oil price risk, caused by COP21, through the purchase of stocks. From an energy policy perspective, it is worth noting that the reliance on imported oil by many countries as a key source of energy, can be very costly, not only just due to climate change induced reasons. For example, Brown and Huntington (2015) analyze the broad macroeconomic costs that arise from the U.S. reliance on imported oil.7

Next, the temporal nature of these relationships is considered. Previous research by BKSW (2017), has already identified dynamic and time-varying integration between different stock markets, and stock and energy markets. When energy and stock markets are highly integrated there are few diversification benefits to investors. Importantly, during periods of financial market crisis, there is no benefit to investors as markets are highly integrated. Thus, investors need to move beyond simple purchases of stocks and energy assets, to a more active management of their portfolios. We show the cost-saving benefits of a naïve buy-and-hold strategy are easily out-performed by more active portfolio management, which considers the degree of integration between oil and stock markets.

The paper is set out as follows: next in the method section, we discuss more fully the literature on financial market integration and how it can be incorporated into the COP21 framework. For brevity, this discussion is not exhaustive and key papers with a detailed literature are mentioned. Then, in the third section, we introduce and describe the stock and oil market data used in the statistical analysis. The fourth section reports the key results from measuring the degree of integration between oil and various stock market portfolios. The use of a rolling estimation procedure allows the construction of a monthly oil-stock integration index that is reported in annual tables for the various portfolios. The final section allows for concluding remarks.

2. Method

The modelling by Vandyck et al. (2016) implies the gradual shift in aggregate demand away from fossil fuels. From the investor perspective, this allows for the gradual substitution of oil for stocks in a portfolio. We accommodate these shifts in demand by considering an international portfolio allocation with time-varying weights of oil and stocks. This approach applies portfolio theory to measuring this relation between oil and stocks using time varying integration coefficients.

Typically, in econometric studies, investigation of the degree of integration between two financial assets, employs the cointegration framework of Johansen (1991) and Escribano and Granger (1998). This framework has practical limitations. For example, Arouri and Fournier (2012) question its use due to instability in time series due to economic

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4 The Middle East and North Africa (MENA) countries include: Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Malta, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, United Arab Emirates, West Bank and Gaza, and Yemen. Ethiopia and Sudan are sometimes included.

5 For example, Batten et al. (2017) and Mensi et al. (2017) and the references mentioned therein, amongst others.

6 This paper does not consider other non-financial assets (e.g. such as housing), but these could also be considered. We thank a conference participant at the 2017 International Symposium on Environment and Energy Finance Issues, IPAG Business School, France for making this point.

7 Note that while the U.S. is now a net exporter of oil it will likely remain an importer of mostly crude oil and export mostly petroleum products such as gasoline and diesel (EIA, 2017).
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