Energy Economics 56 (2016) 1–8

Contents lists available at ScienceDirect

Energy Economics

journal homepage: www.elsevier.com/locate/eneeco

Price differences among crude oils: The private costs of supply disruptions

Robert K. Kaufmann

Department of Earth and Environment, Boston University, Boston, MA 02215, USA

ARTICLE INFO

Article history:
Received 12 March 2015
Received in revised form 25 January 2016
Accepted 2 February 2016
Available online 26 February 2016

JEL classification:
Q4
Q40
Q48

Keywords:
Oil prices
Supply disruption
Country risk
Unified market

ABSTRACT

I quantify the causes for price differences among crude oils that are set by the law of one price with a special emphasis on country risk. For crude oils that are part of the same market, I estimate cointegrating relations, which represent their long-run relation, and error correction models, which represent the rate at which the market eliminates disequilibrium in their prices. Results indicate that positive values of country risk impose a $0.51 price penalty on a barrel of crude oil from an unreliable supplier that increases with the variance in risk and the price of crude oil. These price penalties are the first empirical estimates for how the market values the private costs of oil supply disruptions. Beyond country risk, the price effects of sulfur content, density, distance between supply ports, and OPEC membership confirm the importance of oil supply choke points, OPEC's ability to influence prices, and differences in refinery technology. Because private costs of a supply disruption attach only to nations with a non-zero country risk, previous estimates for the social costs of a supply disruption may be too large.

© 2016 Elsevier B.V. All rights reserved.

1. Introduction

A commodity is defined as a reasonably homogeneous good or material, bought and sold freely as an article of commerce. This definition often is illustrated with the example of crude oil (e.g., Wikipedia, 2014). However, the degree to which crude oil functions as a commodity is part of a debate regarding policies to reduce US reliance on imported oil in general and unreliable foreign suppliers in particular. Such policies will not insulate the US from price spikes and/or supply disruptions if the price of crude oil is governed by the law of one price, which would create a unified oil market. Under these conditions, supply and price disruptions will flow across the globe. Nations that are self-sufficient will experience the same price changes as nations that depend entirely on imports. Conversely, the severity of price and quantity changes will vary among nations if the law of one price does not hold and the crude oil market is regionalized. Under these conditions, crude oil cannot be treated as a commodity.

To date, empirical evidence regarding the nature of the crude oil market is mixed. Econometric analyses generally are consistent with the hypothesis that the market is unified. Univariate test statistics indicate that the prices for many crude oils cointegrate (Rodriguez and Williams, 1993; Gülen, 1997; Gulen, 1999; Ewing and Harter, 2000; Bentzen, 2007; Reboredo, 2011; Kaufmann and Banerjee, 2014). Sharing the same stochastic trend indicates that their prices "move together," which implies that these crude oils are in the same market.

E-mail address: Kaufmann@bu.edu.

http://dx.doi.org/10.1016/j.eneco.2016.02.005
0140-9883/© 2016 Elsevier B.V. All rights reserved.

Conversely, these same univariate test statistics indicate that not all crude oil prices cointegrate and the strength of this relation may vary over time, depending on whether crude oil prices are rising or falling (Milonas and Henker, 2001; Candelon et al., 2012). Consistent with these results, there is evidence that Saudi Arabia uses differences in the price elasticity of demand to set price differences between consumers in Europe and the Far East (Soligo and Jaffee, 2000). Similarly, Kaufmann and Banerjee (2014) find that physical, economic, geographic, and political factors regionalize the world market.

A key to understanding the degree to which crude oil is a commodity lies in Adelman's, 1992 definition of a unified market; if the price of crude oil at two locations differs by more than the transportation cost, arbitrageurs will reduce the price difference between two crude oils to the cost of transport and other fixed costs. Using this notion, I quantify the price differences among crude oil that are set by the law of one price with a special emphasis on risk. As predicted by Adelman (1992) and consistent with previous analyses (Kohli and Morey, 1990; Hartman, 2003; Wang, 2003; Bacon and Tordo, 2005), price differences among crude oils reflect physical and geographic characteristics (e.g., sulfur content, density, and transportation costs). Beyond these characteristics, crude oils from suppliers that are viewed as unreliable are discounted relative to comparable crude oils. These are the first empirical estimates for the private costs of a supply disruption and suggest that previous estimates for the social costs of a supply disruption are too large because they assume that imports from all nations carry the same risk.

These results, and the methods used to obtain them, are described in four sections. The second section describes the data and the statistical methodology that are used to estimate the long- and short-run relations between crude oil prices and how these relations are used to quantify price differences among crude oils. The third section describes the estimation results. In Section 4, these results are used to estimate the price differences among crude oils associated with specific characteristics, which include country risk. Section 5 describes how the price discount associated with country risk can be viewed as the private costs of a supply disruption and how previous estimates for the social costs of a supply disruption may be too large because they assume that imports from all nations carry the same risk.

2. Methodology

2.1. Previous methods

Previous efforts to quantify price differences between crude oils focus largely on physical and geographic characteristics. All analyses of physical characteristics include sulfur content and density (Kohli and Morey, 1990; Hartman, 2003; Wang, 2003; Bacon and Tordo, 2005). Recent efforts also include viscosity, pour point, and Reid vapor pressure (Wang, 2003), or total acid number (Bacon and Tordo, 2005). Location is represented by transportation costs to NW Europe (Bacon and Tordo, 2005) or distance to the US (Kohli and Morey, 1990). Kohli and Morey (1990) include information about national risk as represented by a nation's political reputation and find that friendliness to the US has a positive effect on prices.

The price effects of these variables are quantified using two methodologies: assay-based valuations[1] and statistical models. Statistical models (Hartman, 2003; Bacon and Tordo, 2005) specify the average price difference between monthly crude oil prices over some sample period as the dependent variable. Independent variables include quality differences between crude oils and/or these quality differences multiplied by the price level for a benchmark crude (to capture price differences between crude oils that depend on the price level of crude oil), and variables that represent location. Wang (2003) uses hedonic price equations to estimate an implicit price for sulfur content and density. Kohli and Morey (1990) use a constant elasticity of substitution function to generate implicit estimates for the value of physical, geographic, and political characteristics of crude oil.

2.2. Data

Here, I use the data compiled by Kaufmann and Banerjee (2014) to quantify the price differences between crude oils that the law of one price assigns to the physical, economic, geographic, and political characteristics of crude oils. These data include daily observations for the spot price[2] ($/Bbl) of thirty-three crude oils (Table 1). Prices are compiled by Thomas Reuters Datastream and are reported by ICIS. The sample includes 2113 daily observations from November 27, 2002, through December 31, 2010. For each crude oil, information is compiled on its density (API°), its sulfur content (percent weight), whether the nation of origin is a member of OPEC, its shipping location (latitude and longitude), and the average country risk (and its variance) associated with the producing nation.

During the sample period, crude oil prices vary over a wide range and include a price collapse in the second half of 2008. Such rapid changes in price are critical to the interpretation of results. The analysis is based on the premise that the law of one price generates price differences based on country risk, density, OPEC membership, etc. These effects are measured most precisely by crude oils whose prices follow one another under a variety of conditions, which include periods of rapid increases and decreases. In other words, regardless of market conditions, the law of one price links their prices. Any decoupling would imply that the law of one price breaks down. Without it, one cannot use the price differences to quantify how the market values country risk, etc.

Ratings of risk are obtained from the OECD. These ratings are made by an in-house committee and are based on qualitative assessments of government controls and geopolitical instability. Using the values generated by the OECD implicitly assumes that their ratings are consistent with those made by other agencies, such as the extractive industries transparency initiative or revenue watch. If differences among ratings affect statistical results, there is no *a priori* criterion to choose one set. Unevenly spaced ratings of risk from the OECD are interpolated (using a step function that changes on the date of a new rating) to create daily values. The mean and variance of these daily values are used in the statistical models described below.

Sulfur content is measured by percent sulfur by weight. The density of crude oil is represented by its API gravity.[3] API gravity measures the density of crude oil relative to water, which has a value of 10. A value greater than 10 indicates that a crude oil is lighter than water, with larger values indicating lighter crude oils.

For this analysis, Indonesia is considered a member of OPEC because it dropped out in 2008, which is near the end of the sample period. Results do not change significantly if Indonesia is reclassified as a non-OPEC nation.

2.3. Econometric methodology

Previous analyses (Section 2) implicitly assume that the observed price differences between crude oils represent market-based valuations of physical, economic, geographic, and political factors. This assumption is valid only if the crude oils are governed by the law of one price and their relation is stable over time. To ensure that the prices for the crude oils being compared are governed by the law of one price and their relations are stable over time (i.e., there is no structural break), the first step identifies pairs of crude oil whose prices cointegrate. To test for cointegration, I use the methodology developed by Engle and Granger (1987). Following this procedure, ordinary least squares is used to estimate Eq. (1):

$$P_{it} = \lambda + \psi P_{jt} + \mu_t \tag{1}$$

in which P_i is the spot price for crude oil i on day t, P_j is the spot price for crude oil j, λ and ψ are regression coefficients, and μ and is the regression residual.

The regression residual μ is tested for the presence of a stochastic trend using the ADF statistic[4] (Dickey and Fuller, 1979). If the ADF statistic is more negative than the critical value -3.33 ($p = 0.05$), the null hypothesis that μ contains a unit root is rejected, and the prices for crude oils i and j are said to cointegrate. The critical value used to evaluate the ADF statistic is calculated using formulae from McKinnon (1994). To test the degree to which results regarding cointegration are robust, the ADF statistic also is evaluated against a critical value at the 1% level (-3.90) and the 10% level (-3.04).

A finding of cointegration indicates that the law of one price generates a stable long-run relation between the prices for the two crude oils. To quantify their long-run relation, a dynamic ordinary least squares

[1] Assay-based valuations are based on the yields of standard distillation fractions for a given refining technology. Assay-based methods are more precise for specific crudes and markets, but rely on complex models of refineries that need detailed inputs and therefore cannot be used for empirical analyses of price differences between a wide variety crudes that originate in many nations.

[2] A spot price is the price for a crude oil for immediate payment and delivery at a specific location. As such, they do not include transportation costs.

[3] Degrees API = (141.5/(SG 60 °F/60 °F)) - 131.5 in which SG is the specific gravity of crude oil at 60 °F (http://www.eia.gov/dnav/pet/tbldefs/pet_pri_wco_tbldef2.asp).

[4] The equation used to estimate the ADF statistic specifies a constant but no time trend.

Download English Version:

https://daneshyari.com/en/article/5063957

Download Persian Version:

https://daneshyari.com/article/5063957

Daneshyari.com