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Empirical evidence of news about future prospects in the risk-pricing of oil assets

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ABSTRACT

This empirical paper investigates the relevance of long-run risks associated with uncertainty shocks to future growth prospects (news about future prospects) for explaining the risk-pricing of oil stocks. An econometric method that incorporates dynamic factor analysis is used for estimating the pricing equation of oil stocks. The results indicate that oil investors care about long-run risks associated with future growth prospects. Long-run risks account for almost half of the total risk-premium of oil stocks. Long-run risks associated with future growth prospects are significantly shaped by latent factors related to the labor market, the price indices, and financial markets. Moreover, our estimated model captures some historical events including the oil crisis of the seventies, the economic crisis of the mid-eighties, the stock market crash of 1987, and the economic crises of 1998 and 2000.

1. Introduction

Do long-run risks associated with uncertainty shocks to future growth prospects matter for pricing oil stocks? The role of uncertainty shocks to future growth prospects – news about future prospects – has been mentioned by many studies including Krautkraemer (1998), Graham-Tomasi et al. (1986), and Livernois (2009) as to be a major issue in future research in energy and resource economics. Uncertainty shocks to future growth prospects constitute a risk factor that may shape the pricing of oil stocks. While arguing about the oil market behavior on June 9, 2009 at the Reuters Global Energy Summit, the U.S. Energy Secretary Steven Chu pointed out that: “There's one thing for sure. It is not supply and demand currently … It's all based on future prospects … of what might happen”.[1] In this paper, we analyze the relevance of considering uncertainty shocks to future growth prospects (news about future prospects) as a potential risk factor for the pricing of oil stocks.

The concept of news about future prospects is related to changes in expectations about the long-run future in response to uncertainty shocks to future growth prospects. The recursive utility framework accounts for uncertainty about long-run future prospects in making decisions (Duffie and Epstein, 1992b). With recursive utility, the current utility depends on both the consumption and the future utility index which captures expectations about future consumption prospects. News about future prospects is introduced in the form of future utility growth. A larger future utility index represents brighter future prospects of the economy while a decrease in future utility represents worsening future prospects of the economy. The forward-looking flexible feature of recursive utility allows a potential role for long-run risks associated to future growth prospects to endogenously matter in the investor decision-making (Cochrane, 2005; Hansen, 2010, 2012; Sargent, 2007).

To the best of our knowledge, this is the first empirical study, built on a natural resource risk management model, that investigates the relevance of long-run risks associated with uncertainty shocks to future growth prospects (news about future prospects) for analyzing the risk-pricing of oil stocks. This empirical work builds on (Kakeu, forthcoming) economic model of exhaustible resource extraction that features long-run risk factors associated with future growth prospects in the risk-pricing of oil stocks. Oil stocks can be held as a hedging instrument against bad future prospects if their returns tend to be high

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[1] See the Reuters website http://www.reuters.com/article/idUSTRE55068S20090601.

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when news about future growth prospects is bad. In such a case, holding such an oil stock is desirable for investors averse to long-run risks associated with uncertainty shocks to future growth prospects.

Another novelty of this paper is the use of an econometric approach that incorporates dynamic factor analysis in estimating the pricing equation of the oil stock. The methodology of dynamic factor analysis is a technique that allows information in a large number of economic time series to be summarized by a relatively small number of estimated factors. In the past few years, a growing number of applied works in finance and macroeconomics have used dynamic latent factor models [see for instance Bernanke et al., 2005; Bai and Ng, 2002; Boivin and Giannoni, 2006; Forni et al., 2009; Bernanke and Boivin, 2003; Favero et al., 2005; Bai and Ng, 2002; Bouaddi and Taamouti, 2013; Ludvigson and Ng, 2009; Bouaddi and Taamouti, 2012]. However, to the best of our knowledge this is the first time that the dynamic factor analysis is used in applied work in energy economics. We use the Engle (2002) Dynamic Conditional Correlation model approach to compute the dynamic correlations while estimating the pricing equation. A similar tool is used by Bali and Engle (2010). The data we use are from February 1959 to December 2006. Data on market capitalization of oil companies are from the Center for Research in Security Prices University of Chicago, data on world proven oil reserves are from the web site of BP Statistics, and data on consumption are from the St. Louis Federal Reserve Bank. The data containing the information about the macroeconomic variables come from the DRI–McGraw–Hill Basic Economics database. The financial series are from the Fama–French data library.

The proxy used for the scarcity rent in this paper is the difference between the growth rate of market capitalization of mining firms and that of proved reserves.[2] To justify this choice, we derive a formal relationship between the return on a unit of the resource in the ground and the stock market return of a mining company. We then use the market capitalization of mining companies and proved reserves in the empirical investigation of the risk-pricing of oil stocks in capital markets.

Our results indicate that oil investors care about long-run risks associated with future growth prospects. Long-run risks associated to uncertainty shocks to future growth prospects account for roughly half of the total risk-premium of oil reserves. This underscores the importance of the long-run risk channel for the risk management of oil stocks. Our results are reminiscent of Krautkraemer (1998, p. 2077) who pointed out that changes in expectations about future prospects may affect the valuation of exhaustible energy resource stocks. Our results echoe Bansal and Yaron (2004), Sargent (2007), and Bansal (2007) who emphasize that models incorporating long-run risks have the potential to provide additional channel for understanding investors' behavior. Moreover, our estimated model captures some historical events including the oil crisis of the seventies, the economic crisis of the mid-eighties, the stock market crash of 1987, and the economic crises of 1998 and 2000.

The empirical paper is organized as follows. Section 2 briefly presents the stochastic resource model by Kakeu (2010, forthcoming), that features long-run risk factors associated with future growth prospects in the risk-pricing of oil stocks. Section 3 describes an econometric methodology that incorporates the dynamic factor analysis for estimating the pricing equation of oil stock. Section 4 presents the data. Section 6 presents empirical results for oil. The last section offers concluding comments.

2. Brief presentation of the stochastic resource economic model

2.1. Extraction and production sectors

This empirical paper builds on Kakeu (2010, forthcoming) stochastic resource model in which investment opportunities are permitted as in Gaudet and Khadr (1991), and preferences are represented by a recursive utility à la Duffie and Epstein (1992a). This framework combines a capital markets side and a product and resource markets side. In this economy there are two goods, one of which is a nonrenewable natural resource, whose stock at date t, $S(t)$, is irreversibly reduced by extraction. The other is a reproducible composite good, that can be either consumed or accumulated. If accumulated, it can be either in the form of physical capital, whose accumulated stock is denoted $K(t)$, or of a "bond". The accumulated stock of bonds $B(t)$ is assumed to reproduce itself at an exogenously given risk free rate $r(t)$, which represents the force of interest.

Both the production of the composite good and the extraction of the natural resource are assumed to be stochastic. More precisely, if $y(t)$ denotes the flow of production of the composite good, $x(t)$ denotes the flow of extraction of the resource and $\theta_1(t)$ and $\theta_2(t)$ are two stochastic productivity indices, then the stochastic production and extraction processes are represented respectively by

$$y(t) = F(K_y(t), x(t), \theta_1(t)) \tag{1}$$

and

$$x(t) = G(K_x(t), \theta_2(t)) = \frac{K_x(t)}{\gamma(\theta_2(t))}, \tag{2}$$

where $K_y(t) + K_x(t) = K(t)$.

Eq. (1) says that, at time t, the physical capital $K_y(t)$ is combined with the flow of the extracted resource $x(t)$ to produce the composite good $y(t)$, and the production depends on an exogenous productivity level $\theta_1(t)$. In Eq. (2), $K_x(t)$ is the physical capital devoted to extracting the natural resource; the exogenous productivity level in the extraction sector is $\theta_2(t)$, and $x(t)$ is the extraction flow.[3]

The production of the composite good is assumed to satisfy $F_K > 0$, $F_x > 0$, $F_{KK} < 0$ and $F_{xx} < 0$, and the Inada conditions with respect to the inputs K_y and x. It is also assumed to satisfy $F_1 > 0$, $F_{K1} > 0$ and $F_{x1} > 0$, where the subscript 1 denotes the derivative with respect to θ_1. The function $\gamma(\theta_2)$ represents the number of units of capital required to extract a unit of the natural resource and satisfies $\gamma'(\theta_2) < 0$, $\lim_{\theta_2 \to -\infty} \gamma(\theta_2) = \infty$, and $\lim_{\theta_2 \to \infty} \gamma(\theta_2) = 0$.

The productivity indices θ_1 and θ_2 are assumed to evolve over time according to Itô processes of the form:

$$d\theta_i = \mu_i dt + \sigma_i \xi_i \sqrt{dt}, \quad i = 1,\ 2, \tag{3}$$

with $\xi_i \sim N(0,\ 1)$, $\mathrm{cov}(d\theta_1,\ d\theta_2) = \sigma_{12} dt + o(dt)$ and $\sigma_{12} = \sigma_1 \sigma_2\ \mathrm{cov}(\xi_1,\ \xi_2)$.[4] The drift μ_i and the variance σ_i can depend on time and on the state of the economy.

The dynamic programming problem of the resource extraction sector is to choose the extraction path that maximizes the expected present value of the future net benefits:

$$\max_{x(t),\ t \in [0,\infty]} E \int_0^\infty e^{-\beta t} q(t)[p(t) - r\gamma(\theta_2(t))]x(t)dt \tag{4}$$

subject to:

$$dS(t) = -x(t)dt \quad \text{and} \quad S(0) = S_0 > 0,\ \text{given} \tag{5}$$

where β is the instantaneous time-invariant discount rate, $p(t)$ represents the gross price of a unit of the resource, expressed in units of the composite commodity, and $q(t)$ denotes the demand price of a unit of the composite commodity, taken as given, as is $\theta_2(t)$. The expression $\lambda(t) = p(t) - r(t)\gamma(\theta_2(t))$ is the value of the marginal unit of resource held in the ground, expressed in terms of the composite good. That is the price of the marginal unit of the resource on the flow market $p(t)$, net of the cost of taking it out of the ground $r(t)\gamma(\theta_2(t))$.

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[2] Miller and Upton (1985a) is the pioneering paper that relies on the market values of oil reserves to investigate the Hotelling rule. See also Miller and Upton (1985b).

[3] Then, notice that the cost of extraction is $r(t)K_x(t) = r(t)\gamma(\theta_2(t))x(t)$, $r(t)$ being the opportunity cost of capital.

[4] This is a detailed way to say that $\sigma_i \xi_i \sqrt{dt}$ is normally distributed with expectation zero and variance t — a standard Wiener process.

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