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Abstract

The Hotelling rule argues that the price for a nonrenewable resource adjusts to the shadow value of the resource, reflecting the remaining availability of the resource. We empirically test the Hotelling rule on the effect of unanticipated oil field discoveries. We do not find evidence for a significant adjustment of the price of crude oil to news about greater resource availability and therefore conclude that the price for crude oil does not follow the theoretically optimal price path.

Keywords: Nonrenewable Resource, Oil Price, Exhaustible Resources, Information Acquisition

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1 Introduction

The welfare maximizing solution for extracting a nonrenewable resource by Hotelling (1931) requires two conditions to hold: First, the static efficiency condition claims that the value of extraction from the resource stock is equal to the shadow value. This price component reflects the opportunity cost of using one unit of the resource today rather than tomorrow and arises only due to the fact that the supply of the resource is finite. Second, the dynamic efficiency condition states that the optimally extracted quantity adjusts such that the shadow value increases at a rate of return comparable to an alternative investment.

Unanticipated discoveries of additional resource reservoirs change the current perception of scarcity and induce the often cited chain-saw pattern of resource prices (Dasgupta and Heal, 1979; Krautkraemer, 1998; Perman, 2003)): the shadow value of the resource instantaneously drops, indicating the lower opportunity cost of using the unit today, ceteris paribus. The rate of increase in the shadow price, however, must not change as the rate of return from holding the alternative investment has not changed. Testing the Hotelling rule therefore reduces to testing whether a drop in the price of a nonrenewable resource on the day of an unanticipated discovery indeed takes place (Dasgupta and Heal, 1979). Such an example of using comparative statics to test the Hotelling rule avoids an error-prone reconstruction of the evolution of scarcity rent (Slade, 1982; Stollery, 1983; Farrow, 1985; Young, 1992).

The crucial step for our test is the identification of an unanticipated discovery. While expectations in the market are usually inferred from analyst forecasts, no such information exists on the likeliness and size of future oil field discoveries. We solve this problem by using stock price reactions of oil companies involved in the discovery process to learn about the degree of anticipation of an oil field finding in the market. The following identification mechanism is applied: If the stock price of an involved company shows an abnormal return to news about a discovery, the announcement contains new information. We conclude that the discovery has not been anticipated by market participants (Fama, 1970).

2 Empirical setup

2.1 Identifying the degree of unanticipation

We apply the event study methodology to identify the degree of anticipation in discovery announcements as it is the primary tool to test the value of new information in markets. We determine the benchmark return following (Fama et al., 1969) and introduce dummy variables around discovery days to measure a significant deviation from the benchmark (Mckenzie et al., 2004). A significant estimate of the dummy variable coefficient is interpreted as an abnormal return. In detail, we estimate the following regression:

$$R_{k,t} = \alpha_k + \beta_k R_{m_k,t} + \sum_{i=1}^{L_k} \gamma_{i,k} D_{i,k,t} + e_{k,t}. \tag{1}$$

R_t is the return at time t for the stock of company $k = 1, ..., K$.[1] R_{m_k} is the market index corresponding to the primary listing of the company stock. The dummy variable D_k takes the value of one on the discovery day of field i, denoted as $t = t_i^*$, if company k has participated in the discovery of field i and zero otherwise.[2] L_k denotes the total amount of discoveries company k has participated in. The error term follows an AR(1) process with $e_{k,t} = \rho_k e_{k,t-1} + u_t$ where $u_t \sim N(0,1)$. α, β and γ are coefficients and are estimated with the GLS Prais-Winsten procedure (Greene, 2008).

Corporate media announcements of *Giant* oil field discoveries since 1990 are selected as events.[3] Hook et al. (2009) notes that *Giant* oil fields are crucial for the worldwide supply of oil but are rarely found. The names of Giant oil fields were taken from Mann et al. (2007) and Halbouty (2003). We consider only those fields where at least one of the oil companies involved in the discovery is listed at any stock exchange in the world. The precise discovery day was determined as the day at which at least one of the involved companies officially announced the finding of the particular field. This announcement had to appear in Platt's Oilgram News and in either the London Stock Exchange Aggregated Regulatory News Service or Thomson Financial News to ensure oil as well as stock market investors to have read the news. The announcement had to contain an estimate of the size of the field or a statement from which the finding of a *Giant* could be inferred. For 35 fields, it was possible to collect an announcement that satisfied the above criteria. A total of 38 publicly traded companies participated in the discovery of these fields. The stock price series for these companies are taken from datastream and consist of end-of-the-day data. As stock market indices, the country-specific Dow-Jones index series is used.

[1] $R_t = ln(P_t) - ln(P_{t-1})$ with settlement price P.

[2] As usual for event studies, we build an event window around the actual event:

$$D_{i,t} = \begin{cases} 1 & \text{if } t_i^* - 1 \leq t \leq t_i^* + 1 \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

[3] *Giant* oil fields are defined to contain a minimum of 500 million barrels of ultimately recoverable barrels of oil.

Table (1) about here

Table 1 shows that 20 out of 35 fields have resulted in an abnormal return on the stock price of at least one involved company. Having identified these discoveries as unanticipated, we turn to estimating the existence of an abnormal return on the price of crude oil for these days.

2.2 Does the oil price drop on the day of unanticipated discoveries ?

We determine the impact of unanticipated discovery announcements on the price of crude oil in two steps: First, we investigate whether the unanticipated discoveries have resulted in an abnormal return that is significantly different from zero on average. The following regression is estimated:

$$R_{j,t} = \alpha_j + \beta_j R_{m,t} + \gamma_j D_{j,t} + e_{j,t} \tag{3}$$

$j \epsilon [s, f]$ denotes the spot and futures price series, respectively. R_m is the commodity market index. The dummy variable D takes the value of one on any day that was identified as unanticipated in 2.1 and zero otherwise. The remaining model characteristics are as given in (1) and estimated using the GLS-Prais Winsten procedure (PW-GLS). As robustness check, a fixed effects model is estimated.

In a second step, equation (1) is re-run for the spot and futures price series of oil. As a robustness check, an AR(3)- model of the endogenous variable is estimated (ARMA):[4]

$$R_{j,t} = \alpha_j + \beta_{1,j} R_{j,t-1} + \beta_{2,j} R_{j,t-2} + \beta_{3,j} R_{j,t-3} + \sum_{i=1}^{20} \gamma_{i,j} D_{i,j,t} + e_{j,t}. \tag{4}$$

The WTI Cushing Spot price and the prices of Crude Future contracts for delivery in two months as traded on NYMEX are used. As commodity market index, the CRB commodity index is chosen. All series are taken from datastream.

The results of the first step (Table 2) show that the average abnormal return on days of unanticipated discoveries is not significantly different from zero in any model specification: the coefficient of the dummy variable takes on values between 0.001 and 0.002. Thus, on average, we do not find a significant price movement for crude oil after discovery announcements.

[4]The optimal lag length of three was determined using the varsoc command in Stata.

Table (2) about here.

Investigating the impact for each field individually (Table 3), we find that only a single announcement has resulted in a significantly negative abnormal return. However, the result is not robust as the coefficient is not significantly different from zero in the ARMA model. Some announcements have resulted in positive abnormal returns in the PW-GLS model but they are unsupported by the ARMA model. Overall, the results deny the existence of a systematic drop in the price of crude oil around the days of unanticipated discovery announcements.

Table (3) about here.

3 Discussion & Conclusion

The asymmetric price impact of news cannot be explained by the time lag between discovery and production start as companies face the same time horizon between discovery and actual production start with the risk faced by an individual company being much higher.

Furthermore, news about oil field discoveries renders more precise the availability of crude oil in the nearer future and further clarifies the opportunity cost of using oil today rather than tomorrow. Therefore, the shadow price resembling this opportunity cost consideration should adjust on the day where such information becomes public even if one expects a lot of oil still to exist in the ground.

However, the analysis cannot clarify whether the detected oil field is still too small to result in a significant price movement. In order to disprove this argument we would need to determine the minimum quantity found that leads to a significant shift in prices. As fears about a soon ending of oil frequently hit the headlines, it is surprising that news of greater availability of crude oil do not result in any significant value for the public, at all.

We conclude that the price for crude oil does not adjust to news about lower scarcity and consequently remains on a level too high compared to the optimal price path. Our results provide evidence against an empirical validity of the static efficiency condition and consequently of prices following the Hotelling rule.

A Identification of unanticipated discoveries

Field i	Company k	β_{m_k}	$\gamma_{i,k}$	N / R^2
Akpo	Petrobras	1.121*** (0.011)	0.019** (0.008)	4165 / 0.71
Azar	Lukoil	1.044*** (0.014)	0.007** (0.005)	3136 /0.87
Bonga	Eni	0.937*** (0.027)	0.004* (0.002)	3700 / 0.49
	Shell	0.879*** (0.019)	0.005*** (0.002)	4719/0.53
Buzzard	BG	0.932*** (0.017)	0.003** (0.020)	4720/ 0.27
Carioca	Petrobras		0.004* (0.002)	
Dalia	Elf	0.312* (0.143)	0.030** (0.015)	4718 / 0.085
Erha	Shell		0.021** (0.009)	
Girassol	BP	0.955*** (0.024)	0.009*** (0.002)	4720 / 0.38
	Norskhydro	1.198*** (0.016)	0.007*** (0.003)	7827 / 0.70
Gumusut	ConocoPhillips		0.008*** (0.001)	
Jack	Devon Energy	0.809*** (0.026)	0.025** (0.013)	4720 / 0.17
Kashagan	ConocoPhillips		0.011* (0.006)	
	Exxon	0.739*** (0.031)	0.011*** (0.002)	4720 / 0.31
	Total	0.483* (0.211)	0.011* (0.008)	4719 / 0.23
Kaskida	Anadarko	0.888*** (0.015)	0.006* (0.051)	4720 / 0.19
Knotty Head	BHP Billiton	1.319*** (0.020)	0.007*** (0.008)	4720 / 0.49
PengLai	ConocoPhillips		0.019** (0.008)	
Tahiti	Enterprise Oil	-0.004 (0.035)	0.047*** (0.012)	2704 / 0.006
Tiber	Petrobras		0.014** (0.007)	
Tupi	BG		0.047*** (0.005)	
	GalpEnergia	0.882*** (0.063)	0.122** (0.062)	855/ 0.36
	Petrobras		0.048*** (0.010)	
Ursa	ConocoPhillips	0.786*** (0.034)	0.003* (0.002)	4719/ 0.25
Usan	Esso	0.138 (0.074)	0.009*** (0.003)	4718 / 0.022
WestSeno Complex	Mobil	0.136** (0.050)	0.006* (0.006)	2061 / 0.006

standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: only abnormal returns are displayed.

Table 1: Unanticipated discoveries

B Average abnormal return

Variable	Spot (PW-GLS)	Future (PW-GLS)	Fixed effects
β_j	0.25 (0.02)***	0.22 (0.01)***	0.22 (0.01) ***
γ_j	0.001 (0.002)	0.002 (0.002)	0.002 (0.002)
R^2	0.31%	0.33%	0.28%
N	5152	5152	10304

standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 2: Average abnormal return

C Test for abnormal returns

Field i	$\gamma_{i,s}$		$\gamma_{i,f}$	
	PW-GLS	ARMA	PW-GLS	ARMA
Akpo	0.025** (0.010)	0.024 (0.023)	0.024 (0.018)	0.023** (0.010)
Azar	0.007*** (0.002)	0.010 (0.095)	0.006** (0.003)	0.007 (0.067)
Bonga				
Buzzard			0.011** (0.005)	0.010 (0.035)
Carioca	0.009*** (0.001)	0.011 (0.275)	0.006** (0.003)	0.007 (0.058)
Dalia				
Erha	0.013*** (0.003)	0.012 (0.079)		
Girassol				
Gumusut				
Jack	-0.012** (0.005)	-0.012 (0.051)		
Kashagan				
Kaskida				
Knotty				
Head				
PengLai				
Tahiti			0.013** (0.005)	0.013 (0.030)
Tiber				
Tupi				
Ursa				
Usan				
WestSeno				
R_m	0.253*** (0.068)		0.217*** (0.059)	
$R_{j,t-1}$		-0.052*** (0.006)		-0.023* (0.009)
$R_{j,t-2}$		-0.041*** (0.008)		-0.012 (0.010)
$R_{j,t-3}$		-0.046*** (0.007)		-0.031*** (0.008)
N	5152		5152	
R^2	0.004		0.004	
ll	11293	11294	12262	12256

standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: only abnormal returns are displayed.

Table 3: Regression results

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References

Dasgupta, P., Heal, G., 1979. Economic theory and exhaustible resources. volume 7. Cambridge University Press, Cambridge, UK.

Fama, E.F., 1970. Efficient capital markets: A review of theory and empirical work. J Financ 25, 383–417.

Fama, E.F., Fisher, L., Jensen, M.C., Roll, R., 1969. The adjustment of stock prices to new information. Int Econ Rev 10, 1–21.

Farrow, S., 1985. Testing the efficiency of extraction from a stock resource. J Polit Econ 93, 452–487.

Greene, W.H., 2008. Econometric analysis. 5th ed. Upper Saddle River, New Jersey.

Halbouty, M.T., 2003. Giant oil and gas fields of the decade, 1990-1999. AAPG Memoirs 78.

Hook, M., Hirsch, R., Aleklett, K., 2009. Giant oil field decline rates and their influence on world oil production. Energ Policy 37, 2262–2272.

Hotelling, H., 1931. The Economics of exhaustible resources. J Polit Econ 39, 137–175.

Krautkraemer, J.A., 1998. Nonrenewable resource scarcity. J Econ Lit 36, 2065–2107.

Mann, P., Horn, M., Cross, I., 2007. Emerging trends from 69 giant oil and gas fields discovered from 2000-2006, in: Presentation on April 2, 2007, at the Annual Meeting of the American Association of Petroleum Geologists in Long Beach, California.

Mckenzie, A., Thomsen, M., Dixon, B., 2004. The performance of event study approaches using daily commodity futures returns. J Futures Markets 24, 533–555.

Perman, R., 2003. Natural resource and environmental economics. Pearson Education.

Slade, M., 1982. Trends in natural-resource commodity prices - an analysis of the time domain. J Environ Econ Manag 9, 122–137.

Stollery, K.R., 1983. Mineral depletion with cost as the extraction limit: A model applied to the behavior of prices in the nickel industry. J Environ Econ Manag 10, 151 – 165.

Young, D., 1992. Cost specification and firm behaviour in a hotelling model of resource extraction. Can J Economics 25, pp. 41–59.

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