The Economic Impact of Oil on Industry Portfolios

Jaime Casassus
Universidad Catolica de Chile

Freddy Higuera
Universidad Catolica del Norte

Lausanne, November 2013

Table of Contents

Oil and asset prices

- Oil is an input to the economy (input share of oil is 4% approx).
- Nine out of the last ten US recessions were preceded by an increase in oil prices.
- Business cycle plays a crucial role in stock returns.

⇒ Oil price changes have significant forecasting power for stock market excess returns.

- Oil is a macro variable that affects stock prices, but also affects cash flows of some industries.

⇒ Industry portfolio returns react differently to oil price shocks.

- We build an ad-hoc structural model to quantify the different effects of oil shocks in industry portfolios.

Oil and asset prices (cont.)

- The price of a stock is the present value of its dividends (Gordon, 1959)

$$P_i = \frac{D_i}{r_i - g_i}$$

- The discount rate accounts for the risk of the cash flows (e.g., CAPM of Sharpe, 1964 and Lintner, 1965)

$$r_i = r_f + \beta_i \lambda_m$$

where
  - r_t^f is the risk-free rate
  - β_i is the quantity of systematic risk
  - λ_m is the market risk premium

- The effects of oil price shocks on stock prices can be decomposed in:
  - business-cycle effects through r_t^f and λ_m
  - industry-specific effects through D_i, g_i and β_i

Related literature

- Oil and the macroeconomy
  - Hamilton (1983), Barsky and Kilian (2004), Kilian (2008), Hamilton (2008)
- Oil and the stock market: classic papers
  - Chen, Roll, and Ross (1986), Huang, Masulis, and Stoll (1996), Jones and Kaul (1996), Sadorsky (1999)
- Oil risk factors and the stock market
  - Kilian and Park (2009), Chiang, Hughen, and Sagi (2012), Ready (2013)
- Oil and stock return predictability
  - Casassus and Higuera (2011), Bakshi, Panayotov, and Skoulakis (2011)
- Conditional CAPM and time-varying risk premia
  - Lettau and Ludvigson (2001), Lustig and Van Nieuwerburgh (2005), Santos and Veronesi (2006), Cooper and Priestley (2009)

Table of Contents

The stochastic discount factor

- There is an exogenous *stochastic discount factor* or *pricing kernel*, Λ_t:

$$\frac{d\Lambda_t}{\Lambda_t} = -r_t^f\, dt - \lambda_t\, dZ_{\Lambda,t}$$

- The real risk-free rate, r_t^f, is assumed to be

$$r_t^f = \alpha_0 + \alpha_S \log(S_t) + \alpha_y y_t$$

where S_t is the real oil spot price and y_t is a macro latent factor.

- α_S measures the effect of oil on the real interest rate (e.g., inflationary pressure, monetary policy).

- The market price of risk or *Sharpe ratio*, λ_t, is assumed to be

$$\lambda_t = \theta_0 + \theta_S \log(S_t) + \theta_y y_t$$

The stochastic discount factor

- There is an exogenous *stochastic discount factor* or *pricing kernel*, Λ_t:

$$\frac{d\Lambda_t}{\Lambda_t} = -r_t^f dt - \lambda_t dZ_{\Lambda,t}$$

- The real risk-free rate, r_t^f, is assumed to be

$$r_t^f = \alpha_0 + \alpha_S \log(S_t) + \alpha_y y_t$$

  where S_t is the real oil spot price and y_t is a macro latent factor.

- α_S measures the effect of oil on the real interest rate (e.g., inflationary pressure, monetary policy).

- The market price of risk or *Sharpe ratio*, λ_t, is assumed to be

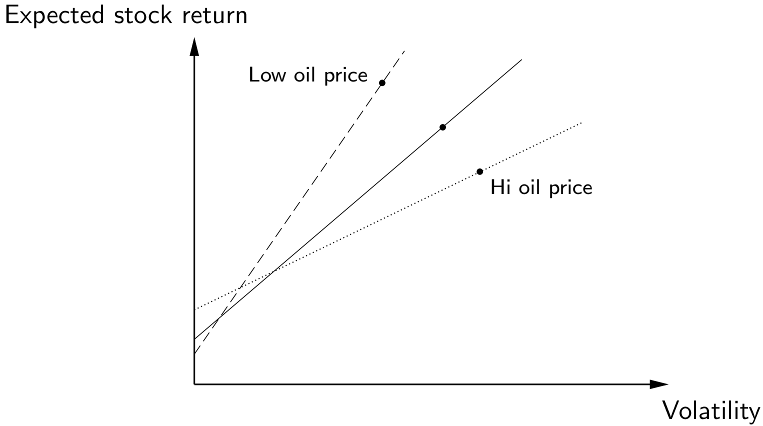
$$\lambda_t = \theta_0 + \theta_S \log(S_t) + \theta_y y_t$$

The stochastic discount factor (cont.)

- θ_S measures the effect of oil on the market price of risk.

$$\lambda_t = \theta_0 + \theta_S \log(S_t) + \theta_y y_t$$

- If $\theta_S < 0$, as suggested by Casassus and Higuera (2011), we have



State variable dynamics

- The real oil price follows a one-factor mean-reverting process:

$$\frac{dS_t}{S_t} = \kappa_S(\bar{s} - \log(S_t))dt + \sigma_S \left(\rho_S dZ_{\Lambda,t} + \sqrt{1-\rho_S^2}\, dZ_{S,t} \right)$$

where $Z_{S,t}$ is an idiosyncratic shock.

- ρ_S measures the systematic component of the oil price shocks.

- The macro latent variable follows a mean-reverting process:

$$dy_t = -\kappa_y y_t dt + \left(\rho_y dZ_{\Lambda,t} + \sqrt{1-\rho_y^2}\, dZ_{y,t} \right)$$

- ρ_y measures the systematic component of the latent variable.

$\Rightarrow$ the oil (log) price and the interest rate follow a VAR(1) process.

State variable dynamics

- The real oil price follows a one-factor mean-reverting process:

$$\frac{dS_t}{S_t} = \kappa_S(\bar{s} - \log(S_t))dt + \sigma_S\left(\rho_S dZ_{\Lambda,t} + \sqrt{1-\rho_S^2}dZ_{S,t}\right)$$

where $Z_{S,t}$ is an idiosyncratic shock.

- ρ_S measures the systematic component of the oil price shocks.

- The macro latent variable follows a mean-reverting process:

$$dy_t = -\kappa_y y_t dt + \left(\rho_y dZ_{\Lambda,t} + \sqrt{1-\rho_y^2}dZ_{y,t}\right)$$

- ρ_y measures the systematic component of the latent variable.

$\Rightarrow$ the oil (log) price and the interest rate follow a VAR(1) process.

Firm dividends and specific parameters

- The firm's cash flows are given by:

$$D^i(X_t^i, q_t^i, S_t) = X_t^i (q_t^i)^{\gamma^i} - S_t q_t^i$$

  where
  - q_t^i is the *endogenous* demand for oil
  - $0 < \gamma^i < 1$ is the firm's oil intensity

- X_t^i captures other factors that affect cash flows and follows:

$$\frac{dX_t^i}{X_t^i} = (\mu_0^i + \mu_S^i \log(S_t))dt + \sigma_I(\text{multiple shocks correlated with other variables})$$

  Also,
  - μ_S^i measures the effect of oil on the growth opportunities of the firm
  - ρ_X^i is correlation between the output shocks and the pricing kernel (cyclicality)
  - ρ_{XS}^i is the correlation between the output shocks and the oil price shocks
  - X_t^i has also an idiosyncratic risk component

- We assume no debt and no adjustment cost in production.

Firm dividends and specific parameters

- The firm's cash flows are given by:

$$D^i(X^i_t, q^i_t, S_t) = X^i_t (q^i_t)^{\gamma^i} - S_t q^i_t$$

where

  - q^i_t is the *endogenous* demand for oil
  - $0 < \gamma^i < 1$ is the firm's oil intensity

- X^i_t captures other factors that affect cash flows and follows:

$$\frac{dX^i_t}{X^i_t} = (\mu^i_0 + \mu^i_S \log(S_t))dt + \sigma_I(\text{multiple shocks correlated with other variables})$$

Also,

  - μ^i_S measures the effect of oil on the growth opportunities of the firm
  - ρ^i_X is correlation between the output shocks and the pricing kernel (cyclicality)
  - ρ^i_{XS} is the correlation between the output shocks and the oil price shocks
  - X^i_t has also an idiosyncratic risk component

- We assume no debt and no adjustment cost in production.

Firm dividends and specific parameters

- The firm's cash flows are given by:

$$D^i(X_t^i, q_t^i, S_t) = X_t^i (q_t^i)^{\gamma^i} - S_t q_t^i$$

  where
  - q_t^i is the *endogenous* demand for oil
  - $0 < \gamma^i < 1$ is the firm's oil intensity

- X_t^i captures other factors that affect cash flows and follows:

$$\frac{dX_t^i}{X_t^i} = (\mu_0^i + \mu_S^i \log(S_t))dt + \sigma_I(\text{multiple shocks correlated with other variables})$$

  Also,
  - μ_S^i measures the effect of oil on the growth opportunities of the firm
  - ρ_X^i is correlation between the output shocks and the pricing kernel (cyclicality)
  - ρ_{XS}^i is the correlation between the output shocks and the oil price shocks
  - X_t^i has also an idiosyncratic risk component

- We assume no debt and no adjustment cost in production.

Firm's value and optimal decision

- The stock price, P^i_t, is the present value of the future dividends:

$$P^i_t = \sup_{\{q^i_u \in \Psi\}} \mathbb{E}_t \left[\int_t^\infty \frac{\Lambda_u}{\Lambda_t} D^i(q^i_u) du \right]$$

- **Proposition 1:** The optimal demand for oil and cash flows of the firm are given by:

$$\begin{aligned}
q^{i*}_t &= \left(\frac{\gamma^i X^i_t}{S_t} \right)^{\frac{1}{1-\gamma^i}} \\
D^{i*}_t &= \left(\frac{(\gamma^i)^{\gamma^i} X^i_t}{S_t^{\gamma^i}} \right)^{\frac{1}{1-\gamma^i}} (1-\gamma^i) \\
\frac{dD^{i*}_t}{D^{i*}_t} &= \left(\frac{(\gamma^i \kappa_S + \mu^i_S) \log(S_t)}{1-\gamma^i} + \varsigma^i \right) dt + \textit{shocks}
\end{aligned}$$

Solution of the model

- Let the price-dividend ratio be:

$$H^i(s_t, y_t) = \frac{P^i(e^{s_t}, y_t, X_t^i)}{D^i(X_t^i, e^{s_t})}$$

- Note that $H^i = \frac{1}{r_i - g_i}$ in the Gordon growth model.

- H_t^i is determined by a HJB equation and has no exact solution.

- We use Campbell and Viceira's (2002) log-linear approximation around the long-term price-dividend ratio.

- **Proposition 2:** The approximated firm's price-dividend ratio is

$$H^i(s_t, y_t) = \exp(a^i + b^i s_t + c^i y_t)$$

where a^i, b^i and c^i are constant coefficients that depend on the parameters of the model.

Stock returns

- Let the instantaneous stock return be

$$\frac{dG_t^i}{G_t^i} = \frac{dP_t^i + D_t^{i^*} dt}{P_t^i}$$

- **Proposition 3:** The instantaneous stock return is

$$\frac{dG_t^i}{G_t^i} = (r_t^f + \eta_\Lambda^i \lambda_t)dt + \eta_\Lambda^i dZ_{\Lambda,t} + \eta_S^i dZ_{S,t} + \eta_y^i dZ_{y,t} + \eta_X^i dZ_{X,t}^i$$

where

$$\eta_\Lambda^i = \left(b^i - \frac{\gamma^i}{1-\gamma^i}\right)\sigma_S \rho_S + c^i \rho_y + \frac{1}{1-\gamma^i}\sigma_X^i \rho_X^i$$

Stock returns

- Let the instantaneous stock return be

$$\frac{dG_t^i}{G_t^i} = \frac{dP_t^i + D_t^{i^*} dt}{P_t^i}$$

- **Proposition 3:** The instantaneous stock return is

$$\frac{dG_t^i}{G_t^i} = (r_t^f + \eta_\Lambda^i \lambda_t)dt + \eta_\Lambda^i dZ_{\Lambda,t} + \eta_S^i dZ_{S,t} + \eta_y^i dZ_{y,t} + \eta_X^i dZ_{X,t}^i$$

  where

$$\eta_\Lambda^i = \left(b^i - \frac{\gamma^i}{1-\gamma^i}\right)\sigma_S \rho_S + c^i \rho_y + \frac{1}{1-\gamma^i}\sigma_X^i \rho_X^i$$

Gordon's model and oil price elasticities

- Price-dividend ratio

$$E^i_{H,S} = \frac{\partial \log(H^i_t)}{\partial \log(S_t)} = b^i$$

- Cash flows / dividends

$$E^i_{D,S} = \frac{\partial \log(D^{i*}_t)}{\partial \log(S_t)} = -\frac{\gamma^i}{1-\gamma^i}$$

- Discount rate

$$E^i_{r,S} = \frac{\partial \frac{1}{dt}\mathbb{E}_t\left[\frac{dG^i_t}{G^i_t}\right]}{\partial \log(S_t)} = \alpha_S + \eta^i_\Lambda \theta_S$$

- Expected dividend growth rate

$$E^i_{g,S} = \frac{\partial \frac{1}{dt}\mathbb{E}_t\left[\frac{dD^{i*}_t}{D^{i*}_t}\right]}{\partial \log(S_t)} = \frac{\gamma^i \kappa_S + \mu^i_S}{1-\gamma^i}$$

Table of Contents

Data and estimation

- We assume that a market portfolio exists

$$\frac{dG^m_t}{G^m_t} = (r^f_t + \sigma_m \lambda_t)dt + \sigma_m dZ_{\Lambda,t}$$

- The panel data for the sample period 1983M04-2010M12 consist of
  - Oil price: crude oil futures with one month to maturity
  - Stock returns: Kenneth French's 17 industry sorted portfolios
  - Market returns: CRSP-VW Index
  - Interest rates: one-month Treasury bill rates
  - Deflator: CPI
- The oil intensity for each industry, γ^i, is calibrated from cash-flow data
- The model is estimated by Maximum Likelihood

Oil intensity, γ_i

- In the model, oil intensity is

$$\gamma^i = \frac{S_t q_t^{i*}}{X_t^i (q_t^{i*})^{\gamma^i}} = \frac{\text{oil expenditure}_i}{\text{sales revenue}_i}$$

- Data from the Manufacturing Energy Consumption Survey (MECS) of EIA

Portfolio		Years				Average
Name	Description	1994	1998	2002	2006	
Food	Food	0.045	0.013	0.018	0.025	0.025
Oil	Oil and Petroleum Products	0.149	0.217	0.153	0.105	0.156
Clths	Textiles, Apparel & Footware	0.021	0.013	0.016	0.017	0.017
Durbl	Consumer Durables	0.016	0.014	0.013	0.014	0.014
Chems	Chemicals	0.125	0.103	0.127	0.142	0.124
Cnsum	Drugs, Soap, Prfums, Tobacco		0.038	0.033	0.038	0.036
Cnstr	Construction and Construction Mat.	0.108	0.035	0.033	0.041	0.054
Steel	Steel Works Etc	0.074	0.060	0.054	0.044	0.058
FabPr	Fabricated Products		0.016	0.017	0.017	0.017
Machn	Machinery and Business Equipment	0.005	0.008	0.009	0.010	0.008
Cars	Automobiles	0.006	0.006	0.006	0.007	0.006
Trans	Transportation		0.007	0.007	0.007	0.007
Rtail	Retail Stores		0.011	0.014	0.017	0.014
Total		9	13	13	13	13

ML estimates - global parameters

Parameter	Estimate	t-stat
σ_m	0.162	26.04
α_0	0.037	3.18
α_S	-0.007	-1.75
α_y	0.162	19.31
θ_0	1.692	4.02
θ_S	-0.445	-3.46
θ_y	-0.878	-7.87
$\bar{s}$	3.476	9.10
κ_S	0.124	2.30
σ_S	0.289	25.81
ρ_S	-0.049	-1.48
κ_y	8.146	7.90
ρ_y	-0.169	-3.20
Log-likelihood	9829.848	

ML estimates - global parameters

Parameter	Estimate	t-stat
σ_m	0.162	26.04
α_0	0.037	3.18
α_S	-0.007	-1.75
α_y	0.162	19.31
θ_0	1.692	4.02
θ_S	-0.445	-3.46
θ_y	-0.878	-7.87
$\bar{s}$	3.476	9.10
κ_S	0.124	2.30
σ_S	0.289	25.81
ρ_S	-0.049	-1.48
κ_y	8.146	7.90
ρ_y	-0.169	-3.20
Log-likelihood	9829.848	

ML estimates - global parameters

Parameter	Estimate	t-stat
σ_m	0.162	26.04
α_0	0.037	3.18
α_S	-0.007	-1.75
α_y	0.162	19.31
θ_0	1.692	4.02
θ_S	-0.445	-3.46
θ_y	-0.878	-7.87
$\bar{s}$	3.476	9.10
κ_S	0.124	2.30
σ_S	0.289	25.81
ρ_S	-0.049	-1.48
κ_y	8.146	7.90
ρ_y	-0.169	-3.20
Log-likelihood	9829.848	

ML estimates - global parameters

Parameter	Estimate	t-stat
σ_m	0.162	26.04
α_0	0.037	3.18
α_S	-0.007	-1.75
α_y	0.162	19.31
θ_0	1.692	4.02
θ_S	-0.445	-3.46
θ_y	-0.878	-7.87
$\bar{s}$	3.476	9.10
κ_S	0.124	2.30
σ_S	0.289	25.81
ρ_S	-0.049	-1.48
κ_y	8.146	7.90
ρ_y	-0.169	-3.20
Log-likelihood	9829.848	

ML estimates - portfolio parameters

- σ_X^i is the volatility of the output growth rate, $\frac{dX_t^i}{X_t^i}$
- ρ_X^i measures the cyclicality of the firm's output
- μ_S^i measures the effect of oil on the growth opportunities of the firm

Portfolio	σ_X^i		ρ_X^i		μ_S^i	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
Food	0.153	25.68	0.670	22.07	-0.067	-4.53
Oil	0.145	25.70	0.630	19.08	-0.024	-1.75
Clths	0.222	25.29	0.789	34.51	-0.117	-4.54
Durbl	0.204	19.75	0.810	20.47	-0.111	-3.86
Chems	0.182	21.12	0.789	22.59	-0.086	-4.02
Cnsum	0.156	25.75	0.680	23.11	-0.071	-4.43
Cnstr	0.206	16.10	0.816	15.20	-0.123	-3.92
Steel	0.276	22.25	0.787	24.25	-0.118	-3.64
FabPr	0.195	22.60	0.797	24.13	-0.098	-4.41
Machn	0.265	13.94	0.826	13.27	-0.145	-3.07
Cars	0.238	24.98	0.761	28.93	-0.119	-4.70
Trans	0.193	22.64	0.800	26.07	-0.102	-3.77
Rtail	0.187	22.16	0.809	23.04	-0.103	-3.09

ML estimates - portfolio parameters

- σ_X^i is the volatility of the output growth rate, $\frac{dX_t^i}{X_t^i}$
- ρ_X^i measures the cyclicality of the firm's output
- μ_s^i measures the effect of oil on the growth opportunities of the firm

Portfolio	σ_X^i		ρ_X^i		μ_S^i	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
Food	0.153	25.68	0.670	22.07	-0.067	-4.53
Oil	0.145	25.70	0.630	19.08	-0.024	-1.75
Clths	0.222	25.29	0.789	34.51	-0.117	-4.54
Durbl	0.204	19.75	0.810	20.47	-0.111	-3.86
Chems	0.182	21.12	0.789	22.59	-0.086	-4.02
Cnsum	0.156	25.75	0.680	23.11	-0.071	-4.43
Cnstr	0.206	16.10	0.816	15.20	-0.123	-3.92
Steel	0.276	22.25	0.787	24.25	-0.118	-3.64
FabPr	0.195	22.60	0.797	24.13	-0.098	-4.41
Machn	0.265	13.94	0.826	13.27	-0.145	-3.07
Cars	0.238	24.98	0.761	28.93	-0.119	-4.70
Trans	0.193	22.64	0.800	26.07	-0.102	-3.77
Rtail	0.187	22.16	0.809	23.04	-0.103	-3.09

ML estimates - portfolio parameters

- σ_X^i is the volatility of the output growth rate, $\frac{dX_t^i}{X_t^i}$
- ρ_X^i measures the cyclicality of the firm's output
- μ_S^i measures the effect of oil on the growth opportunities of the firm

Portfolio	σ_X^i		ρ_X^i		μ_S^i	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
Food	0.153	25.68	0.670	22.07	-0.067	-4.53
Oil	0.145	25.70	0.630	19.08	-0.024	-1.75
Clths	0.222	25.29	0.789	34.51	-0.117	-4.54
Durbl	0.204	19.75	0.810	20.47	-0.111	-3.86
Chems	0.182	21.12	0.789	22.59	-0.086	-4.02
Cnsum	0.156	25.75	0.680	23.11	-0.071	-4.43
Cnstr	0.206	16.10	0.816	15.20	-0.123	-3.92
Steel	0.276	22.25	0.787	24.25	-0.118	-3.64
FabPr	0.195	22.60	0.797	24.13	-0.098	-4.41
Machn	0.265	13.94	0.826	13.27	-0.145	-3.07
Cars	0.238	24.98	0.761	28.93	-0.119	-4.70
Trans	0.193	22.64	0.800	26.07	-0.102	-3.77
Rtail	0.187	22.16	0.809	23.04	-0.103	-3.09

ML estimates - portfolio parameters

- σ_x^i is the volatility of the output growth rate, $\frac{dX_t^i}{X_t^i}$
- ρ_x^i measures the cyclicality of the firm's output
- μ_s^i measures the effect of oil on the growth opportunities of the firm

Portfolio	σ_X^i		ρ_X^i		μ_S^i	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
Food	0.153	25.68	0.670	22.07	-0.067	-4.53
Oil	0.145	25.70	0.630	19.08	-0.024	-1.75
Clths	0.222	25.29	0.789	34.51	-0.117	-4.54
Durbl	0.204	19.75	0.810	20.47	-0.111	-3.86
Chems	0.182	21.12	0.789	22.59	-0.086	-4.02
Cnsum	0.156	25.75	0.680	23.11	-0.071	-4.43
Cnstr	0.206	16.10	0.816	15.20	-0.123	-3.92
Steel	0.276	22.25	0.787	24.25	-0.118	-3.64
FabPr	0.195	22.60	0.797	24.13	-0.098	-4.41
Machn	0.265	13.94	0.826	13.27	-0.145	-3.07
Cars	0.238	24.98	0.761	28.93	-0.119	-4.70
Trans	0.193	22.64	0.800	26.07	-0.102	-3.77
Rtail	0.187	22.16	0.809	23.04	-0.103	-3.09

ML estimates - portfolio parameters

- σ_X^i is the volatility of the output growth rate, $\frac{dX_t^i}{X_t^i}$
- ρ_X^i measures the cyclicality of the firm's output
- μ_S^i measures the effect of oil on the growth opportunities of the firm

Portfolio	σ_X^i		ρ_X^i		μ_S^i	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
Food	0.153	25.68	0.670	22.07	-0.067	-4.53
Oil	0.145	25.70	0.630	19.08	-0.024	-1.75
Clths	0.222	25.29	0.789	34.51	-0.117	-4.54
Durbl	0.204	19.75	0.810	20.47	-0.111	-3.86
Chems	0.182	21.12	0.789	22.59	-0.086	-4.02
Cnsum	0.156	25.75	0.680	23.11	-0.071	-4.43
Cnstr	0.206	16.10	0.816	15.20	-0.123	-3.92
Steel	0.276	22.25	0.787	24.25	-0.118	-3.64
FabPr	0.195	22.60	0.797	24.13	-0.098	-4.41
Machn	0.265	13.94	0.826	13.27	-0.145	-3.07
Cars	0.238	24.98	0.761	28.93	-0.119	-4.70
Trans	0.193	22.64	0.800	26.07	-0.102	-3.77
Rtail	0.187	22.16	0.809	23.04	-0.103	-3.09

ML estimates - portfolio parameters

- σ_X^i is the volatility of the output growth rate, $\frac{dX_t^i}{X_t^i}$
- ρ_X^i measures the cyclicality of the firm's output
- μ_S^i measures the effect of oil on the growth opportunities of the firm

Portfolio	σ_X^i		ρ_X^i		μ_S^i	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
Food	0.153	25.68	0.670	22.07	-0.067	-4.53
Oil	0.145	25.70	0.630	19.08	-0.024	-1.75
Clths	0.222	25.29	0.789	34.51	-0.117	-4.54
Durbl	0.204	19.75	0.810	20.47	-0.111	-3.86
Chems	0.182	21.12	0.789	22.59	-0.086	-4.02
Cnsum	0.156	25.75	0.680	23.11	-0.071	-4.43
Cnstr	0.206	16.10	0.816	15.20	-0.123	-3.92
Steel	0.276	22.25	0.787	24.25	-0.118	-3.64
FabPr	0.195	22.60	0.797	24.13	-0.098	-4.41
Machn	0.265	13.94	0.826	13.27	-0.145	-3.07
Cars	0.238	24.98	0.761	28.93	-0.119	-4.70
Trans	0.193	22.64	0.800	26.07	-0.102	-3.77
Rtail	0.187	22.16	0.809	23.04	-0.103	-3.09

Oil price elasticities

Portfolio	cash flow	price-div	price	div growth	discount
Food	-0.03	-0.08	-0.10	-0.07	-0.05
Oil	-0.19	0.34	0.15	-0.01	-0.05
Clths	-0.02	-0.20	-0.22	-0.12	-0.09
Durbl	-0.01	-0.19	-0.21	-0.11	-0.08
Chems	-0.14	0.00	-0.14	-0.08	-0.08
Cnsum	-0.04	-0.08	-0.12	-0.07	-0.06
Cnstr	-0.06	-0.24	-0.30	-0.12	-0.09
Steel	-0.06	-0.05	-0.11	-0.12	-0.11
FabPr	-0.02	-0.13	-0.15	-0.10	-0.08
Machn	-0.01	-0.26	-0.27	-0.15	-0.11
Cars	-0.01	-0.20	-0.21	-0.12	-0.09
Trans	-0.01	-0.17	-0.18	-0.10	-0.08
Rtail	-0.01	-0.18	-0.19	-0.10	-0.08

- An oil price increase of 10% reduces the value of the non-oil industry portfolios by 1.8% on average.

Oil price elasticities

Portfolio	cash flow	price-div	price	div growth	discount
Food	-0.03	-0.08	-0.10	-0.07	-0.05
Oil	-0.19	0.34	0.15	-0.01	-0.05
Clths	-0.02	-0.20	-0.22	-0.12	-0.09
Durbl	-0.01	-0.19	-0.21	-0.11	-0.08
Chems	-0.14	0.00	-0.14	-0.08	-0.08
Cnsum	-0.04	-0.08	-0.12	-0.07	-0.06
Cnstr	-0.06	-0.24	-0.30	-0.12	-0.09
Steel	-0.06	-0.05	-0.11	-0.12	-0.11
FabPr	-0.02	-0.13	-0.15	-0.10	-0.08
Machn	-0.01	-0.26	-0.27	-0.15	-0.11
Cars	-0.01	-0.20	-0.21	-0.12	-0.09
Trans	-0.01	-0.17	-0.18	-0.10	-0.08
Rtail	-0.01	-0.18	-0.19	-0.10	-0.08

- An oil price increase of 10% reduces the value of the non-oil industry portfolios by 1.8% on average.

Oil price elasticities

Portfolio	cash flow	price-div	price	div growth	discount
Food	-0.03	-0.08	-0.10	-0.07	-0.05
Oil	-0.19	0.34	0.15	-0.01	-0.05
Clths	-0.02	-0.20	-0.22	-0.12	-0.09
Durbl	-0.01	-0.19	-0.21	-0.11	-0.08
Chems	-0.14	0.00	-0.14	-0.08	-0.08
Cnsum	-0.04	-0.08	-0.12	-0.07	-0.06
Cnstr	-0.06	-0.24	-0.30	-0.12	-0.09
Steel	-0.06	-0.05	-0.11	-0.12	-0.11
FabPr	-0.02	-0.13	-0.15	-0.10	-0.08
Machn	-0.01	-0.26	-0.27	-0.15	-0.11
Cars	-0.01	-0.20	-0.21	-0.12	-0.09
Trans	-0.01	-0.17	-0.18	-0.10	-0.08
Rtail	-0.01	-0.18	-0.19	-0.10	-0.08

- An oil price increase of 10% reduces the value of the non-oil industry portfolios by 1.8% on average.

Oil price elasticities

Portfolio	cash flow	price-div	price	div growth	discount
Food	-0.03	-0.08	-0.10	-0.07	-0.05
Oil	-0.19	0.34	0.15	-0.01	-0.05
Clths	-0.02	-0.20	-0.22	-0.12	-0.09
Durbl	-0.01	-0.19	-0.21	-0.11	-0.08
Chems	-0.14	0.00	-0.14	-0.08	-0.08
Cnsum	-0.04	-0.08	-0.12	-0.07	-0.06
Cnstr	-0.06	-0.24	-0.30	-0.12	-0.09
Steel	-0.06	-0.05	-0.11	-0.12	-0.11
FabPr	-0.02	-0.13	-0.15	-0.10	-0.08
Machn	-0.01	-0.26	-0.27	-0.15	-0.11
Cars	-0.01	-0.20	-0.21	-0.12	-0.09
Trans	-0.01	-0.17	-0.18	-0.10	-0.08
Rtail	-0.01	-0.18	-0.19	-0.10	-0.08

- An oil price increase of 10% reduces the value of the non-oil industry portfolios by 1.8% on average.

Oil price elasticities

Portfolio	cash flow	price-div	price	div growth	discount
Food	-0.03	-0.08	-0.10	-0.07	-0.05
Oil	-0.19	0.34	0.15	-0.01	-0.05
Clths	-0.02	-0.20	-0.22	-0.12	-0.09
Durbl	-0.01	-0.19	-0.21	-0.11	-0.08
Chems	-0.14	0.00	-0.14	-0.08	-0.08
Cnsum	-0.04	-0.08	-0.12	-0.07	-0.06
Cnstr	-0.06	-0.24	-0.30	-0.12	-0.09
Steel	-0.06	-0.05	-0.11	-0.12	-0.11
FabPr	-0.02	-0.13	-0.15	-0.10	-0.08
Machn	-0.01	-0.26	-0.27	-0.15	-0.11
Cars	-0.01	-0.20	-0.21	-0.12	-0.09
Trans	-0.01	-0.17	-0.18	-0.10	-0.08
Rtail	-0.01	-0.18	-0.19	-0.10	-0.08

- An oil price increase of 10% reduces the value of the non-oil industry portfolios by 1.8% on average.

Oil price elasticities

Portfolio	cash flow	price-div	price	div growth	discount
Food	-0.03	-0.08	-0.10	-0.07	-0.05
Oil	-0.19	0.34	0.15	-0.01	-0.05
Clths	-0.02	-0.20	-0.22	-0.12	-0.09
Durbl	-0.01	-0.19	-0.21	-0.11	-0.08
Chems	-0.14	0.00	-0.14	-0.08	-0.08
Cnsum	-0.04	-0.08	-0.12	-0.07	-0.06
Cnstr	-0.06	-0.24	-0.30	-0.12	-0.09
Steel	-0.06	-0.05	-0.11	-0.12	-0.11
FabPr	-0.02	-0.13	-0.15	-0.10	-0.08
Machn	-0.01	-0.26	-0.27	-0.15	-0.11
Cars	-0.01	-0.20	-0.21	-0.12	-0.09
Trans	-0.01	-0.17	-0.18	-0.10	-0.08
Rtail	-0.01	-0.18	-0.19	-0.10	-0.08

- An oil price increase of 10% reduces the value of the non-oil industry portfolios by 1.8% on average.

Oil price elasticities

Portfolio	cash flow	price-div	price	div growth	discount
Food	-0.03	-0.08	-0.10	-0.07	-0.05
Oil	-0.19	0.34	0.15	-0.01	-0.05
Clths	-0.02	-0.20	-0.22	-0.12	-0.09
Durbl	-0.01	-0.19	-0.21	-0.11	-0.08
Chems	-0.14	0.00	-0.14	-0.08	-0.08
Cnsum	-0.04	-0.08	-0.12	-0.07	-0.06
Cnstr	-0.06	-0.24	-0.30	-0.12	-0.09
Steel	-0.06	-0.05	-0.11	-0.12	-0.11
FabPr	-0.02	-0.13	-0.15	-0.10	-0.08
Machn	-0.01	-0.26	-0.27	-0.15	-0.11
Cars	-0.01	-0.20	-0.21	-0.12	-0.09
Trans	-0.01	-0.17	-0.18	-0.10	-0.08
Rtail	-0.01	-0.18	-0.19	-0.10	-0.08

- An oil price increase of 10% reduces the value of the non-oil industry portfolios by 1.8% on average.

Oil price elasticities

Portfolio	cash flow	price-div	price	div growth	discount
Food	-0.03	-0.08	-0.10	-0.07	-0.05
Oil	-0.19	0.34	0.15	-0.01	-0.05
Clths	-0.02	-0.20	-0.22	-0.12	-0.09
Durbl	-0.01	-0.19	-0.21	-0.11	-0.08
Chems	-0.14	0.00	-0.14	-0.08	-0.08
Cnsum	-0.04	-0.08	-0.12	-0.07	-0.06
Cnstr	-0.06	-0.24	-0.30	-0.12	-0.09
Steel	-0.06	-0.05	-0.11	-0.12	-0.11
FabPr	-0.02	-0.13	-0.15	-0.10	-0.08
Machn	-0.01	-0.26	-0.27	-0.15	-0.11
Cars	-0.01	-0.20	-0.21	-0.12	-0.09
Trans	-0.01	-0.17	-0.18	-0.10	-0.08
Rtail	-0.01	-0.18	-0.19	-0.10	-0.08

- An oil price increase of 10% reduces the value of the non-oil industry portfolios by 1.8% on average.

Oil price elasticities

Portfolio	cash flow	price-div	price	div growth	discount
Food	-0.03	-0.08	-0.10	-0.07	-0.05
Oil	-0.19	0.34	0.15	-0.01	-0.05
Clths	-0.02	-0.20	-0.22	-0.12	-0.09
Durbl	-0.01	-0.19	-0.21	-0.11	-0.08
Chems	-0.14	0.00	-0.14	-0.08	-0.08
Cnsum	-0.04	-0.08	-0.12	-0.07	-0.06
Cnstr	-0.06	-0.24	-0.30	-0.12	-0.09
Steel	-0.06	-0.05	-0.11	-0.12	-0.11
FabPr	-0.02	-0.13	-0.15	-0.10	-0.08
Machn	-0.01	-0.26	-0.27	-0.15	-0.11
Cars	-0.01	-0.20	-0.21	-0.12	-0.09
Trans	-0.01	-0.17	-0.18	-0.10	-0.08
Rtail	-0.01	-0.18	-0.19	-0.10	-0.08

- An oil price increase of 10% reduces the value of the non-oil industry portfolios by 1.8% on average.

Out-of-sample test for the market log price-dividend ratio

- Log price-dividend ratio

$$\log H_t^i = a^i + b^i \log(S_t) + c^i y_t$$

- Assumption: $\log(S_t)$ and y_t are independent $\Rightarrow$ OLS estimation

	Model	OLS
Constant	4.161	4.155
		(30.17)
$\log(S_t)$	-0.122	-0.131
		(-2.78)
R^2		0.023

Out-of-sample test for the market log price-dividend ratio

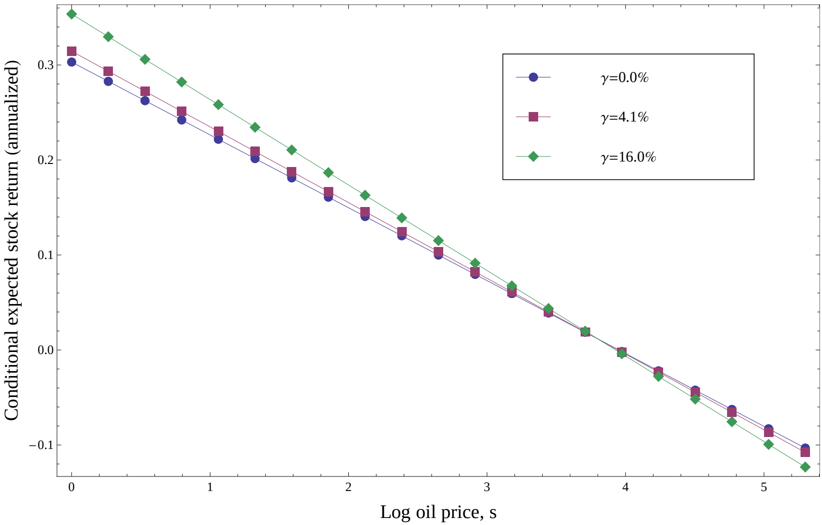
- Log price-dividend ratio

$$\log H_t^i = a^i + b^i \log(S_t) + c^i y_t$$

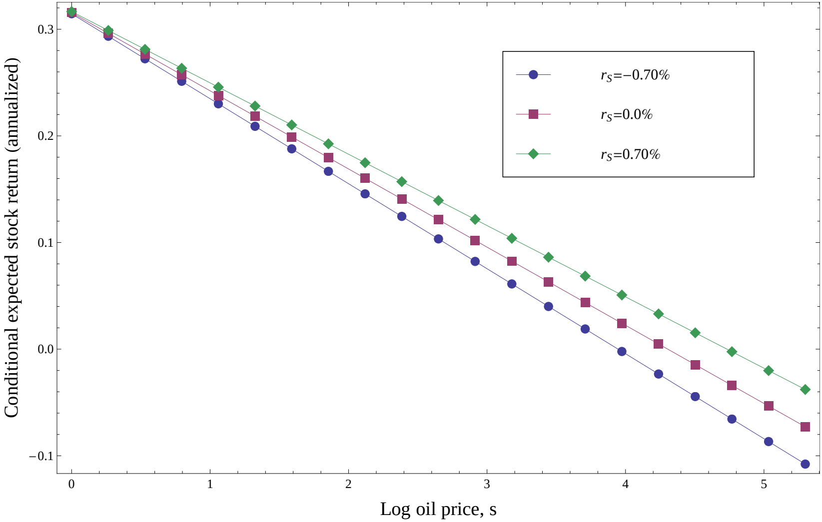
- Assumption: $\log(S_t)$ and y_t are independent $\Rightarrow$ OLS estimation

	Model	OLS
Constant	4.161	4.155
		(30.17)
$\log(S_t)$	-0.122	-0.131
		(-2.78)
R^2		0.023

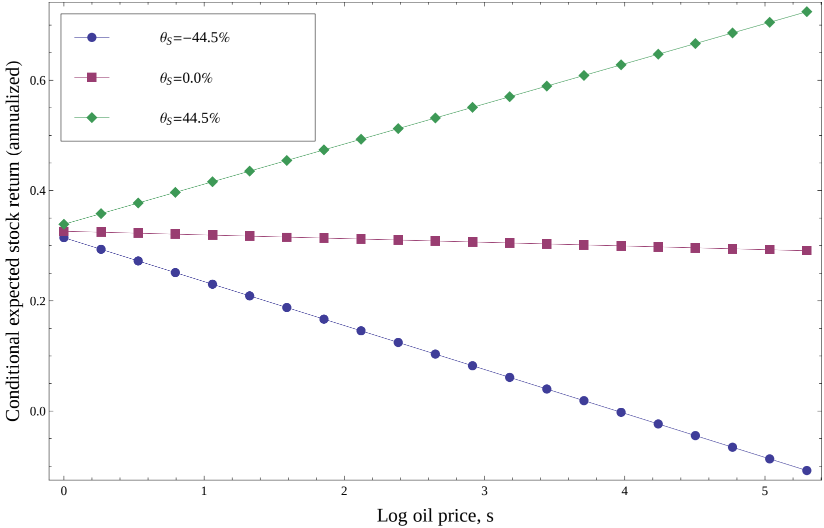
Expected stock returns and oil intensity



Expected stock returns and interest rates



Expected stock returns and the Sharpe ratio



Stock return volatilities

- Stock return dynamics

$$\frac{dG_t^i}{G_t^i} = (r_t^f + \eta_\Lambda^i \lambda_t)dt + \eta_\Lambda^i dZ_{\Lambda,t} + \eta_S^i dZ_{S,t} + \eta_y^i dZ_{y,t} + \eta_X^i dZ_{X,t}^i$$

Portfolio	η_Λ^i	η_S^i	η_y^i	η_X^i
Food	0.108	-0.016	-0.008	0.116
Oil	0.107	0.052	-0.008	0.133
Clths	0.181	-0.030	0.000	0.135
Durbl	0.171	-0.010	-0.001	0.111
Chems	0.167	0.006	-0.002	0.119
Cnsum	0.113	-0.021	-0.007	0.118
Cnstr	0.182	-0.025	0.000	0.110
Steel	0.231	0.024	0.005	0.172
FabPr	0.161	-0.009	-0.002	0.115
Machn	0.224	0.000	0.004	0.129
Cars	0.185	-0.023	0.000	0.151
Trans	0.158	-0.012	-0.003	0.110
Rtail	0.157	-0.028	-0.003	0.108

Stock return volatilities

- Stock return dynamics

$$\frac{dG_t^i}{G_t^i} = (r_t^f + \eta_\Lambda^i \lambda_t)dt + \eta_\Lambda^i dZ_{\Lambda,t} + \eta_S^i dZ_{S,t} + \eta_y^i dZ_{y,t} + \eta_X^i dZ_{X,t}^i$$

Portfolio	η_Λ^i	η_S^i	η_y^i	η_X^i
Food	0.108	-0.016	-0.008	0.116
Oil	0.107	0.052	-0.008	0.133
Clths	0.181	-0.030	0.000	0.135
Durbl	0.171	-0.010	-0.001	0.111
Chems	0.167	0.006	-0.002	0.119
Cnsum	0.113	-0.021	-0.007	0.118
Cnstr	0.182	-0.025	0.000	0.110
Steel	0.231	0.024	0.005	0.172
FabPr	0.161	-0.009	-0.002	0.115
Machn	0.224	0.000	0.004	0.129
Cars	0.185	-0.023	0.000	0.151
Trans	0.158	-0.012	-0.003	0.110
Rtail	0.157	-0.028	-0.003	0.108

Stock return volatilities

- Stock return dynamics

$$\frac{dG_t^i}{G_t^i} = (r_t^f + \eta_\Lambda^i \lambda_t)dt + \eta_\Lambda^i dZ_{\Lambda,t} + \eta_S^i dZ_{S,t} + \eta_y^i dZ_{y,t} + \eta_X^i dZ_{X,t}^i$$

Portfolio	η_Λ^i	η_S^i	η_y^i	η_X^i
Food	0.108	-0.016	-0.008	0.116
Oil	0.107	0.052	-0.008	0.133
Clths	0.181	-0.030	0.000	0.135
Durbl	0.171	-0.010	-0.001	0.111
Chems	0.167	0.006	-0.002	0.119
Cnsum	0.113	-0.021	-0.007	0.118
Cnstr	0.182	-0.025	0.000	0.110
Steel	0.231	0.024	0.005	0.172
FabPr	0.161	-0.009	-0.002	0.115
Machn	0.224	0.000	0.004	0.129
Cars	0.185	-0.023	0.000	0.151
Trans	0.158	-0.012	-0.003	0.110
Rtail	0.157	-0.028	-0.003	0.108

Systematic risk decomposition (CAPM)

- Systematic risk of state variables: $\beta_s = -0.087$ and $\beta_y = -1.045$
- CAPM β's for each industry

$$\beta^i = \left(b^i - \frac{\gamma^i}{1-\gamma^i} \right) \beta_s + c^i \beta_y + \frac{1}{1-\gamma^i} \beta_x^i$$

Portfolio	$\left(b^i - \frac{\gamma^i}{1-\gamma^i} \right) \beta_S$	$c^i \beta_y$	$\frac{1}{1-\gamma^i} \beta_X^i$	β^i
Food	0.009	0.009	0.648	0.666
Oil	-0.013	0.009	0.667	0.663
Clths	0.019	0.000	1.100	1.119
Durbl	0.018	0.002	1.035	1.055
Chems	0.012	0.002	1.016	1.030
Cnsum	0.010	0.008	0.682	0.701
Cnstr	0.026	0.000	1.099	1.125
Steel	0.010	-0.005	1.426	1.430
FabPr	0.013	0.003	0.979	0.995
Machn	0.024	-0.004	1.365	1.385
Cars	0.018	0.000	1.128	1.145
Trans	0.015	0.003	0.961	0.979
Rtail	0.017	0.003	0.949	0.969

Systematic risk decomposition (CAPM)

- Systematic risk of state variables: $\beta_s = -0.087$ and $\beta_y = -1.045$
- CAPM β's for each industry

$$\beta^i = \left(b^i - \frac{\gamma^i}{1-\gamma^i}\right)\beta_s + c^i\beta_y + \frac{1}{1-\gamma^i}\beta_x^i$$

Portfolio	$\left(b^i - \frac{\gamma^i}{1-\gamma^i}\right)\beta_S$	$c^i\beta_y$	$\frac{1}{1-\gamma^i}\beta_X^i$	β^i
Food	0.009	0.009	0.648	0.666
Oil	-0.013	0.009	0.667	0.663
Clths	0.019	0.000	1.100	1.119
Durbl	0.018	0.002	1.035	1.055
Chems	0.012	0.002	1.016	1.030
Cnsum	0.010	0.008	0.682	0.701
Cnstr	0.026	0.000	1.099	1.125
Steel	0.010	-0.005	1.426	1.430
FabPr	0.013	0.003	0.979	0.995
Machn	0.024	-0.004	1.365	1.385
Cars	0.018	0.000	1.128	1.145
Trans	0.015	0.003	0.961	0.979
Rtail	0.017	0.003	0.949	0.969

Systematic risk decomposition (CAPM)

- Systematic risk of state variables: $\beta_s = -0.087$ and $\beta_y = -1.045$
- CAPM β's for each industry

$$\beta^i = \left(b^i - \frac{\gamma^i}{1-\gamma^i}\right)\beta_s + c^i\beta_y + \frac{1}{1-\gamma^i}\beta_x^i$$

Portfolio	$\left(b^i - \frac{\gamma^i}{1-\gamma^i}\right)\beta_S$	$c^i\beta_y$	$\frac{1}{1-\gamma^i}\beta_X^i$	β^i
Food	0.009	0.009	0.648	0.666
Oil	-0.013	0.009	0.667	0.663
Clths	0.019	0.000	1.100	1.119
Durbl	0.018	0.002	1.035	1.055
Chems	0.012	0.002	1.016	1.030
Cnsum	0.010	0.008	0.682	0.701
Cnstr	0.026	0.000	1.099	1.125
Steel	0.010	-0.005	1.426	1.430
FabPr	0.013	0.003	0.979	0.995
Machn	0.024	-0.004	1.365	1.385
Cars	0.018	0.000	1.128	1.145
Trans	0.015	0.003	0.961	0.979
Rtail	0.017	0.003	0.949	0.969

Expected stock returns for Oil and Steel industries

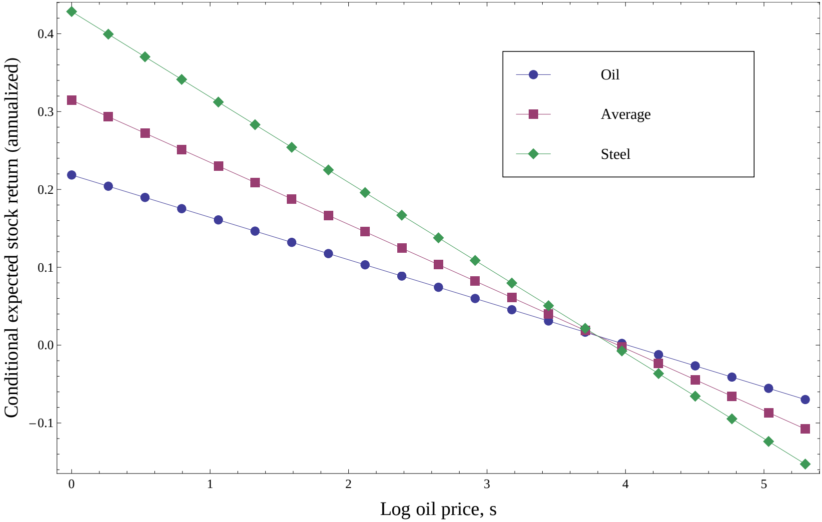


Table of Contents

Conclusions

- We build an ah-hoc model to quantify the effect of oil on industry portfolios.
- An oil price increase of 10%
  - reduces the value of the non-oil industry portfolios by 1.8%
  - increases the value of the oil industry portfolio by 1.5%
  - decreases the expected dividend growth rate of non-oil portfolios by 1.1%
- Conditional expected returns are decreasing in the oil price.
  - Interest rates and Sharpe ratios are negatively affected by oil price shocks.
- Industries with higher systematic risk have expected returns that are more affected by the oil price.
- CAPM betas of the industries are mainly driven by their output.
- Realized stock returns are also affected by oil price shocks.

References

Bakshi, G., G. Panayotov, and G. Skoulakis (2011): "The Baltic Dry Index as a Predictor of Global Stock Returns, Commodity Returns, and Global Economic Activity," Working Paper, University of Maryland.

Barsky, R. B., and L. Kilian (2004): "Oil and the Macroeconomy since the 1970s," *Journal of Economic Perspectives*, 18(4), 115–134.

Campbell, J. Y., and L. M. Viceira (2002): *Strategic Asset Allocation*. Oxford University Press.

Casassus, J., and F. Higuera (2011): "Stock Return Predictability and Oil Prices," Working Paper, Universidad Catolica de Chile.

Chen, N.-F., R. Roll, and S. A. Ross (1986): "Economic Forces and the Stock Market," *Journal of Business*, 59(3), 383–403.

Chiang, I.-H. E., W. K. Hughen, and J. S. Sagi (2012): "Estimating Oil Risk Factors Using Information from Equity and Futures Markets," Working Paper, University of North Carolina.

Cooper, I., and R. Priestley (2009): "Time-Varying Risk Premiums and the Output Gap," *Review of Financial Studies*, 22(7), 2801–2833.

Hamilton, J. D. (1983): "Oil and the Macroeconomy since World War II," *Journal of Political Economy*, 91(2), 228–248.

——— (2008): "oil and the macroeconomy," in *The New Palgrave Dictionary of Economics*, ed. by S. N. Durlauf, and L. E. Blume. Palgrave Macmillan, Basingstoke.

Huang, R. D., R. W. Masulis, and H. R. Stoll (1996): "Energy Shocks and Financial Markets," *Journal of Futures Markets*, 16(1), 1–27.

Jones, C. M., and G. Kaul (1996): "Oil and the Stock Markets," *Journal of Finance*, 51(2), 463–491.