# Estimating the Effect of Price on Oil Production: Evidence from the Norwegian Continental Shelf

Johannes Mauritzen

Department of Business and Management Science
NHH Norwegian School of Economics

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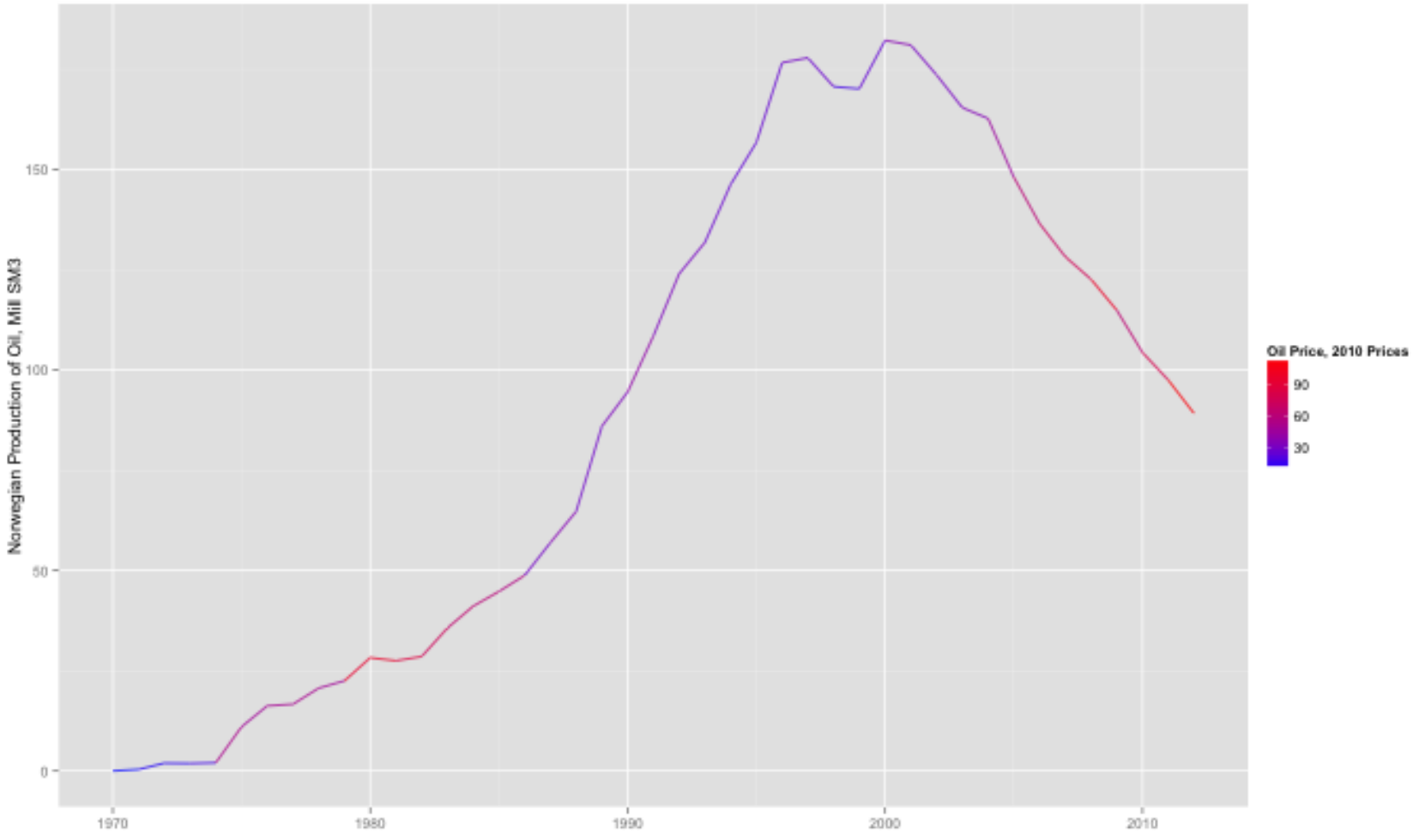

Norwegian Production of Oil, Mill SM3
150
100
50
0
1970
1980
1990
2000
2010
Oil Price, 2010 Prices
90
60
30

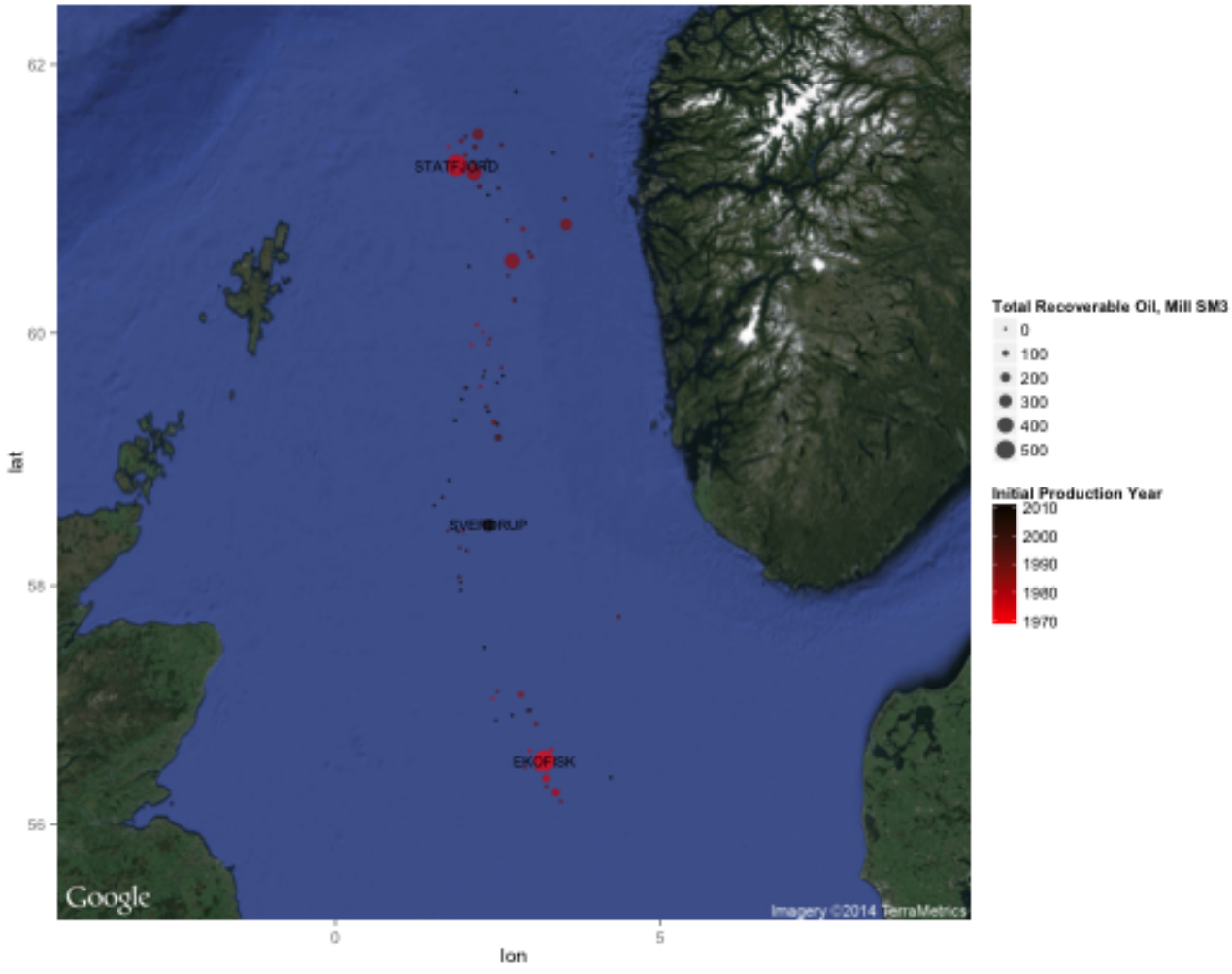
- Effect of Price on Drilling / Reserve Replacement
  - Mohn and Osmundsen (2008), Mohn (2008), Ringlund (2008)
- Aggregate Production
  - Curve-fitting/Simulation (geo-engineering)
  - Econometric
    - Kaufman (1990), Kaufman and Cleveland (2001)
    - Ramcharran (2002)
- Field-level
  - Rao (2012)

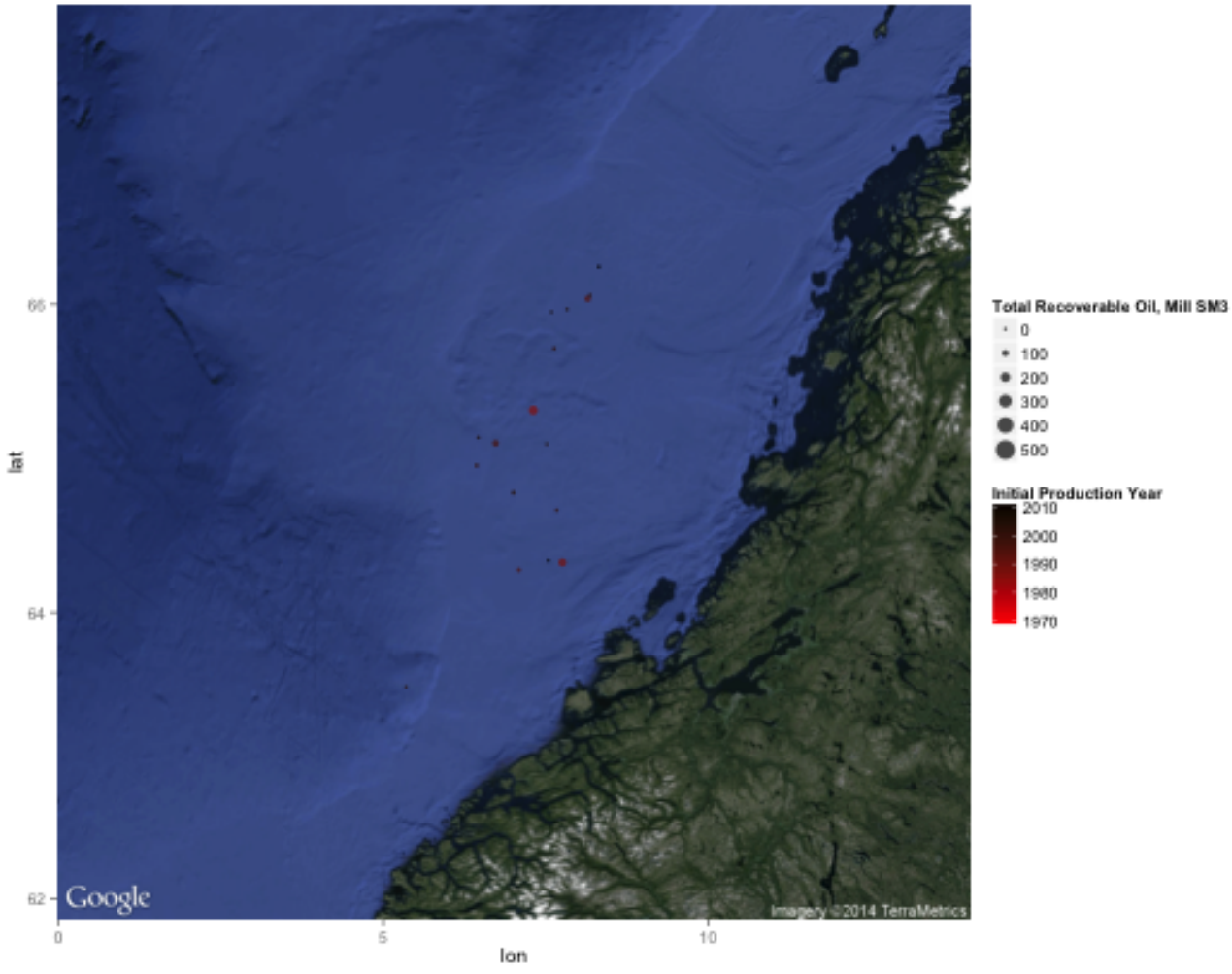
Generalized Additive Models

- Hastie and Tibshirani (1990)
- Wood (2006)

Main Results

- No significant contemporary effect of oil price on field production (within 3 years)
- Slight lagged effect found after 4-8 years, magnitude of around 2%
- Most of this effect seems to come in the planning stage of an oil field
- Little to no effect - contemporary or lagged - in depleting fields


62
60
58
56
lat
STATFJORD
SVEIN RUP
EKOFISK
Google
Imagery ©2014 TerraMetrics
0
5
lon
Total Recoverable Oil, Mill SM3
0
100
200
300
400
500
Initial Production Year
2010
2000
1990
1980
1970


lat
66
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0
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Total Recoverable Oil, Mill SM3
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100
200
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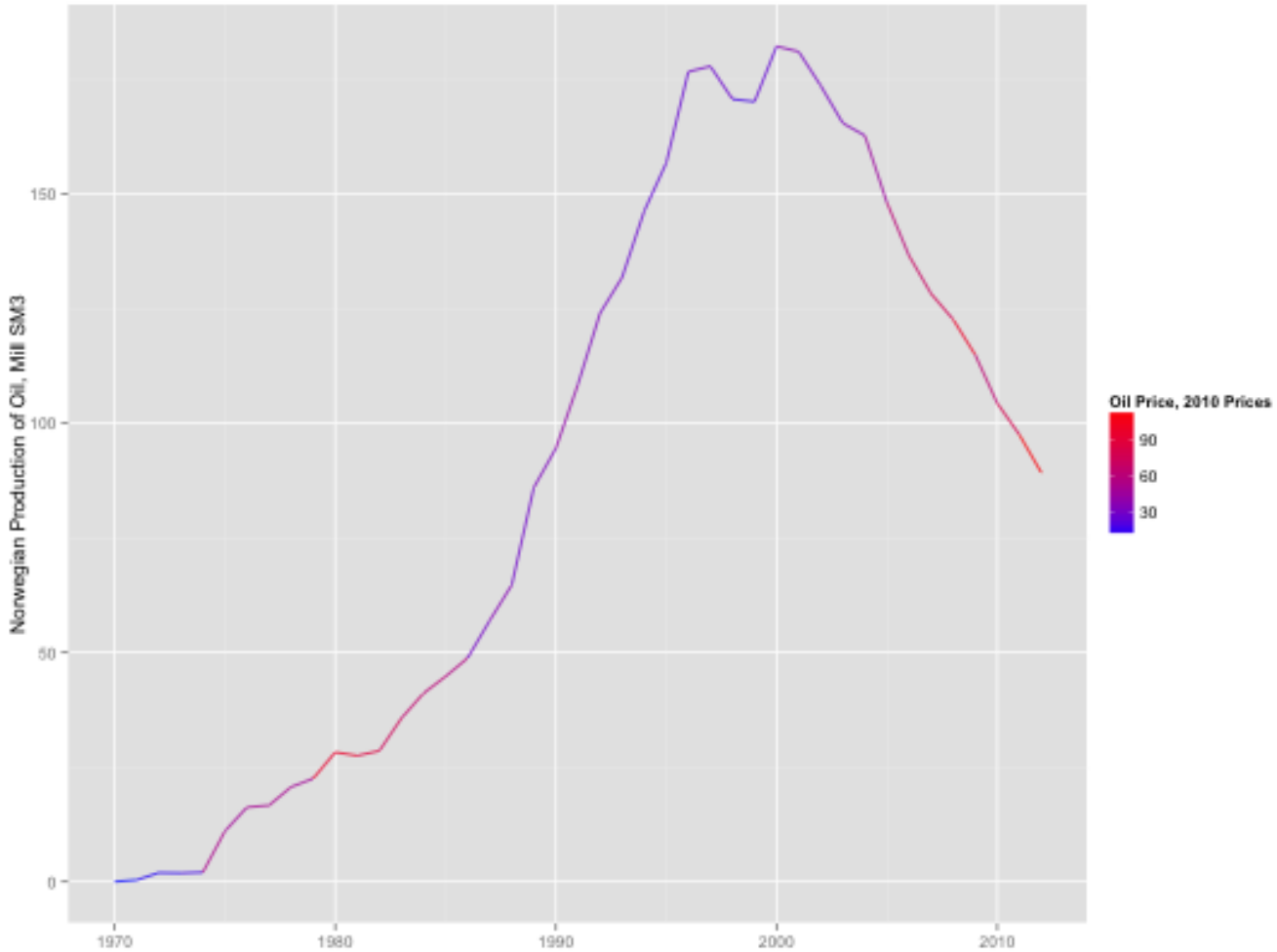
400
500
Initial Production Year
2010
2000
1990
1980
1970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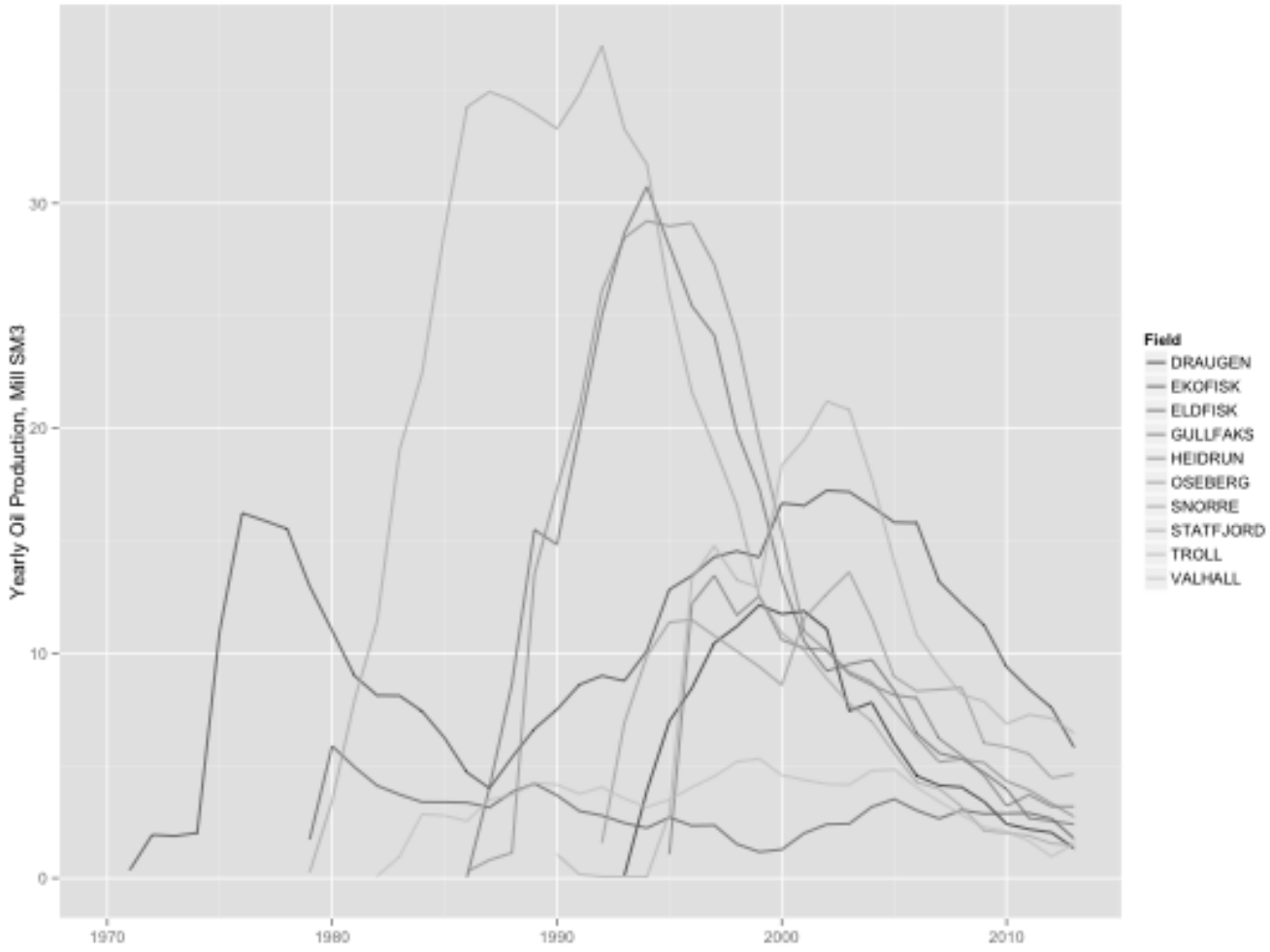
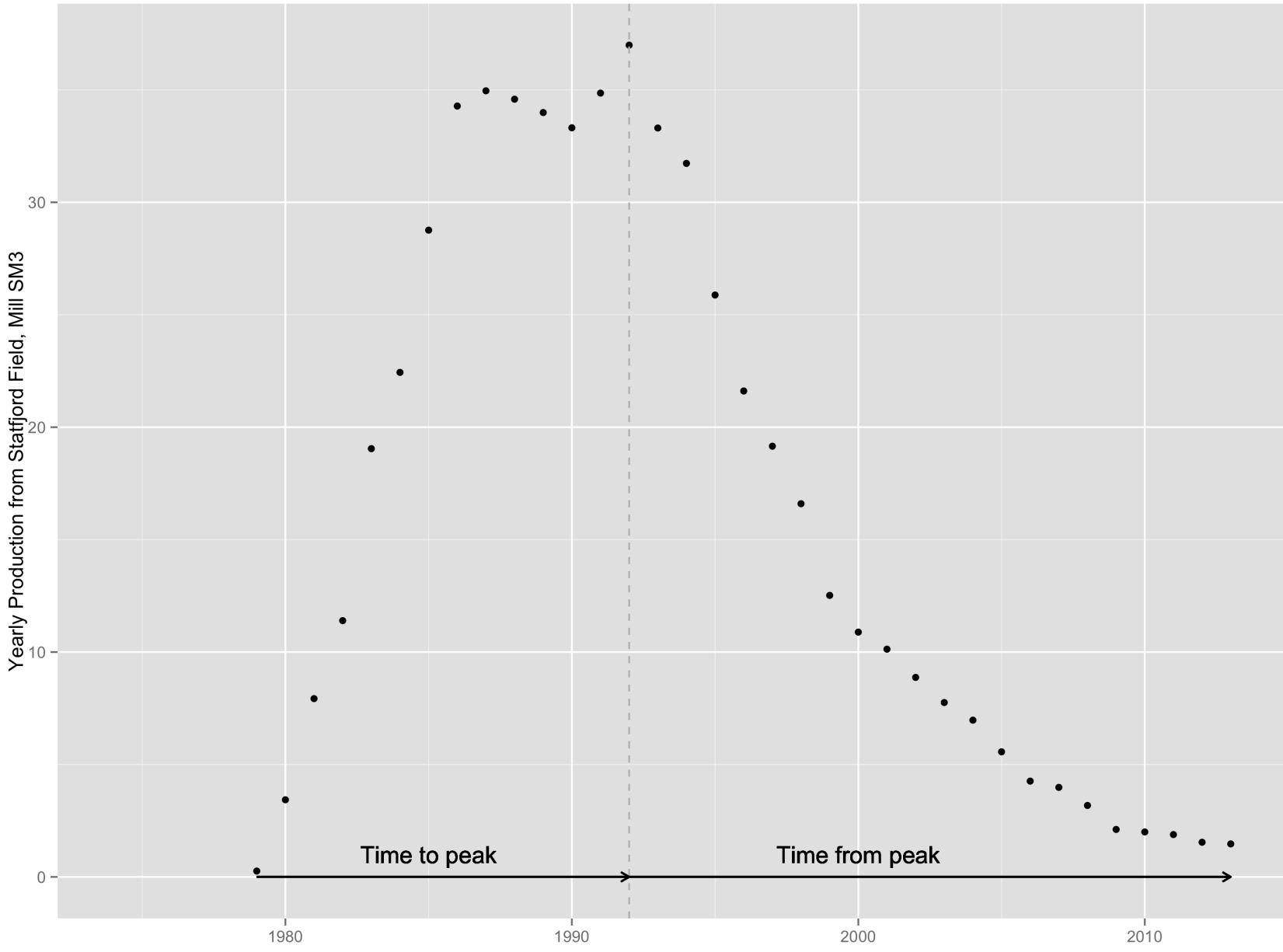
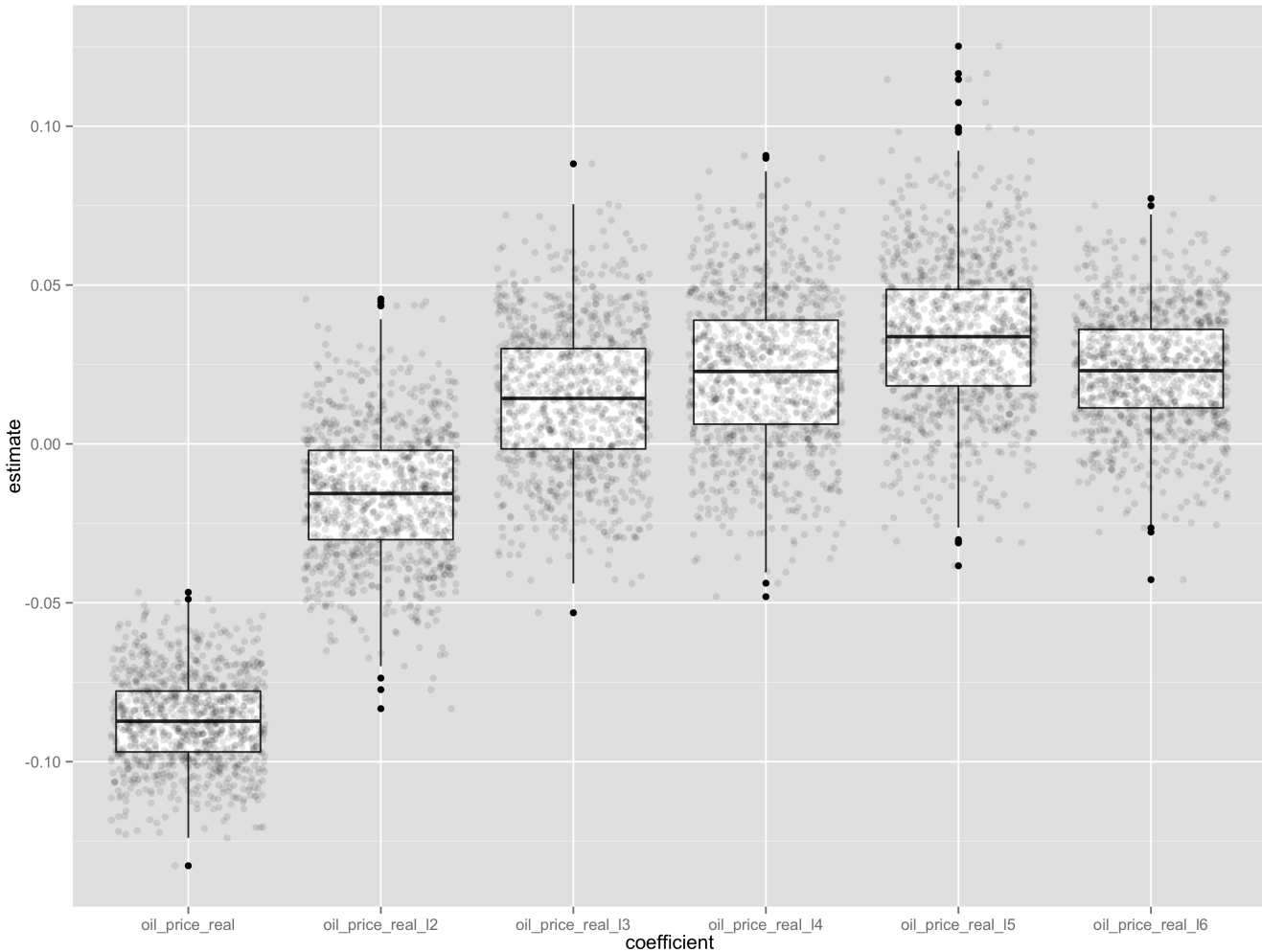
60
30


Yearly Oil Production, Mill SM3
30
20
10
0
1970
1980
1990
2000
2010
Field
DRAUGEN
EKOFISK
ELDFISK
GULLFAKS
HEIDRUN
OSEBERG
SNORRE
STATFJORD
TROLL
VALHALL

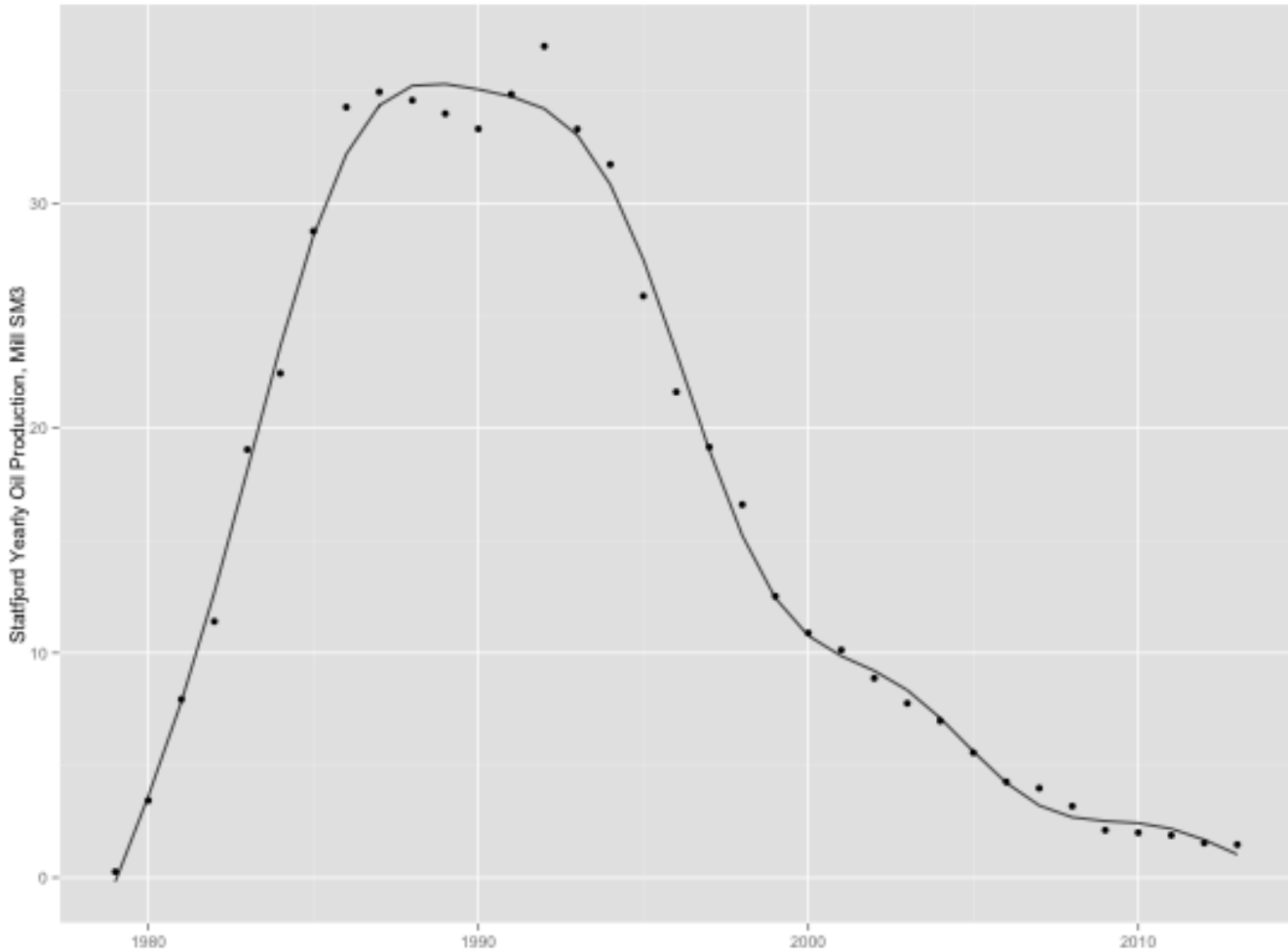

Yearly Production from Statfjord Field, Mill SM3
30
20
10
0
1980
1990
2000
2010
Time to peak
Time from peak

$$
\begin{aligned}
Log(Production_{i,t}) = \alpha_0 &+ Poly(time\_to\_peak_{i,t}) \\
&+ Poly(peak\_to\_end_{i,t}) \\
&+ \gamma total\_recoverable\_oil_i \\
&+ \beta oil\_price_{t,t-1,t-2,..,t-n} + \epsilon
\end{aligned}
\tag{1}
$$


0.10
0.05
0.00
-0.05
-0.10
estimate
oil_price_real
oil_price_real_l2
oil_price_real_l3
oil_price_real_l4
oil_price_real_l5
oil_price_real_l6
coefficient

$$
\begin{aligned}
Log(Production_{i,t}) = & f(time\_to\_peak_{i,t}, total\_recoverable\_oil_i) \\
& + f(peak\_to\_end_{i,t}, total\_recoverable\_oil_i) \\
& + \beta oil\_price_{t,t-1,t-2,..,t-n} + \epsilon
\end{aligned}
\tag{2}
$$

$$Production_t = f(time) + \epsilon \tag{3}$$


Statfjord Yearly Oil Production, Mill SM3
30
20
10
0
1980
1990
2000
2010

$$
\begin{aligned}
Log(Production_{i,t}) = & f(time\_to\_peak_{i,t}, total\_recoverable\_oil_i) \\
& + f(peak\_to\_end_{i,t}, total\_recoverable\_oil_i) \\
& + \beta oil\_price_{t,t-1,t-2,..,t-n} + \epsilon
\end{aligned}
\tag{4}
$$

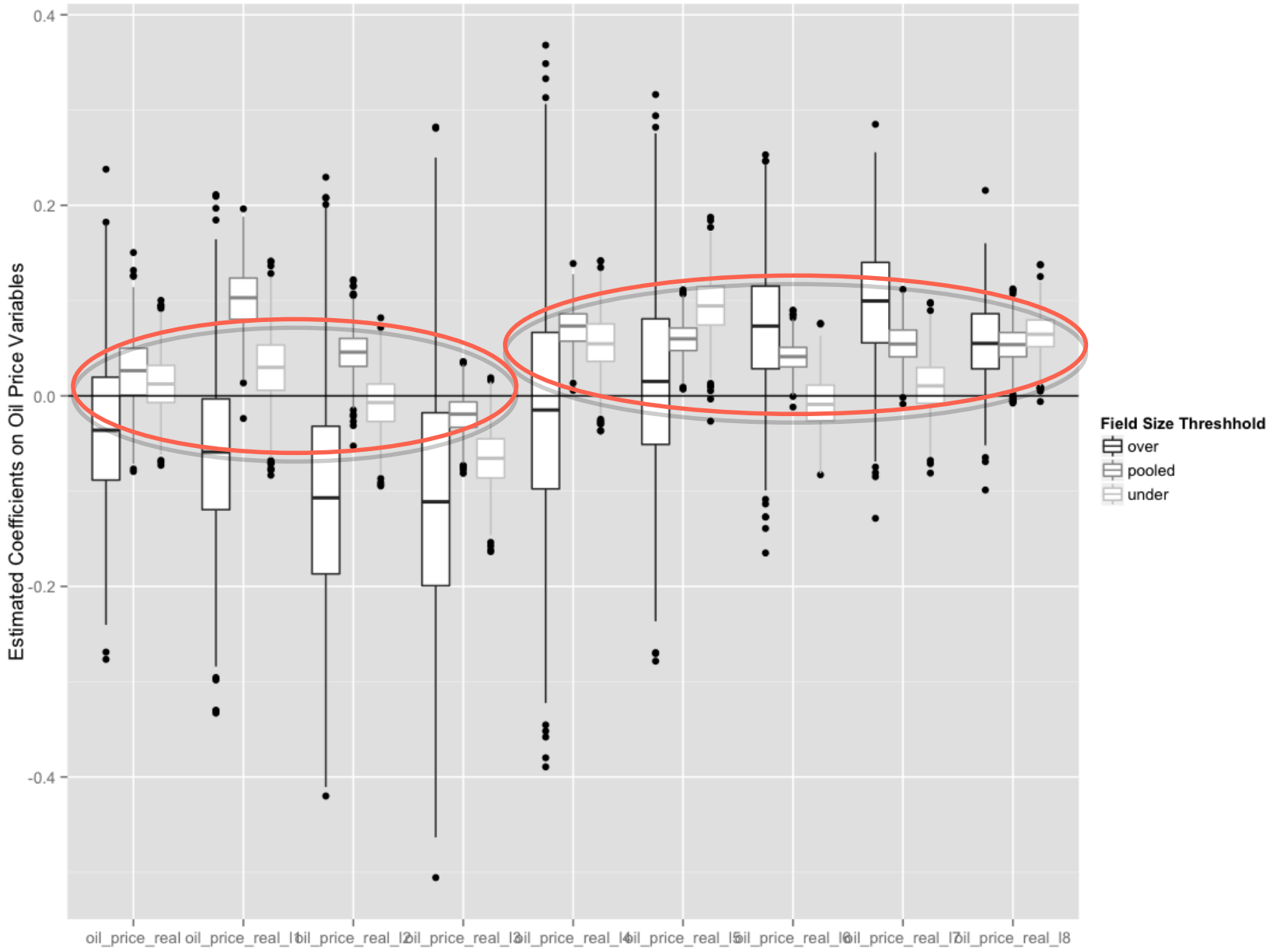
Thin Plate (Regression) Splines (Duchon 1977)

$$y_i = g(x_1, x_2) \tag{5}$$

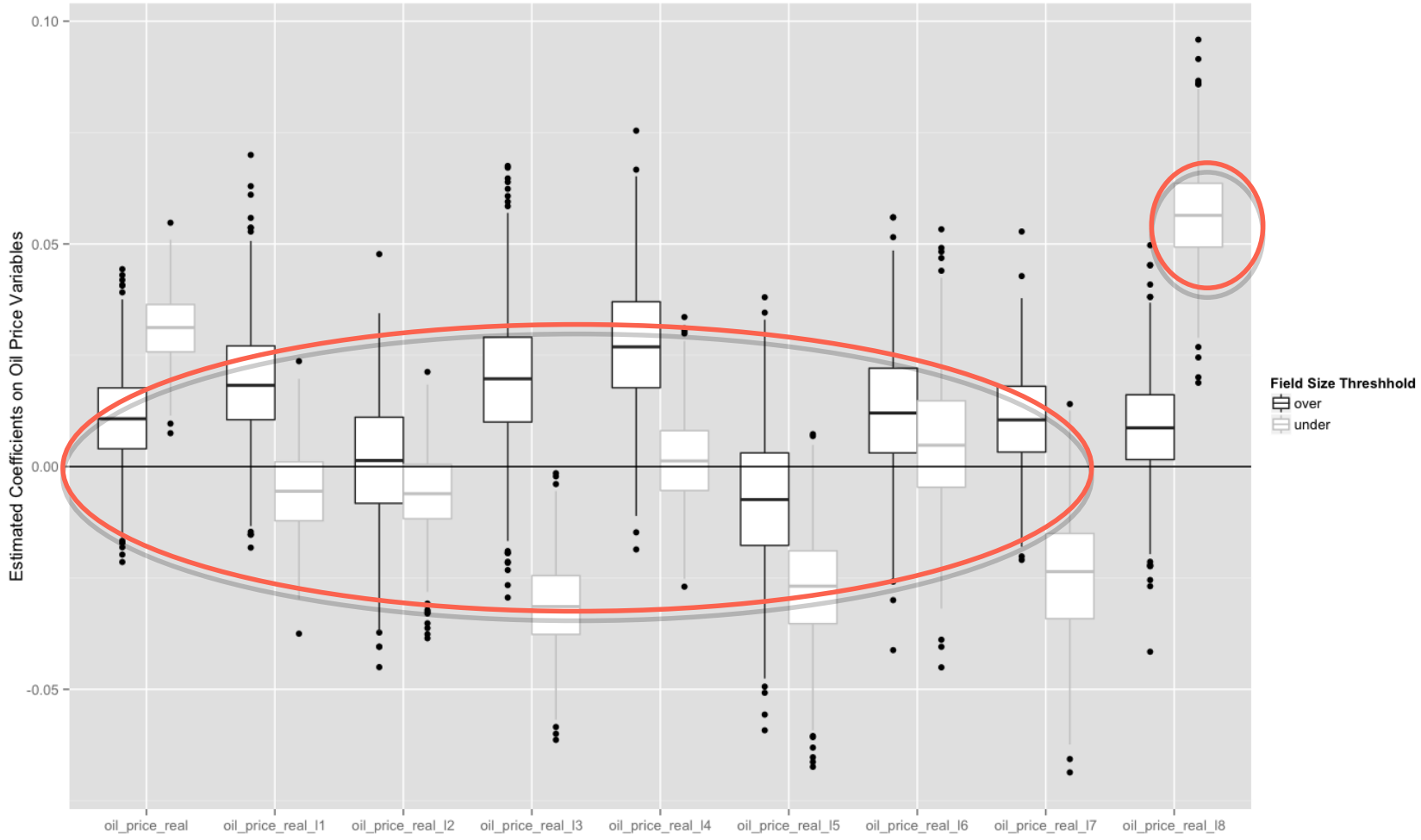
$$\min \|\mathbf{y} - \mathbf{f}\|^2 + \lambda J_{md}(f) \tag{6}$$

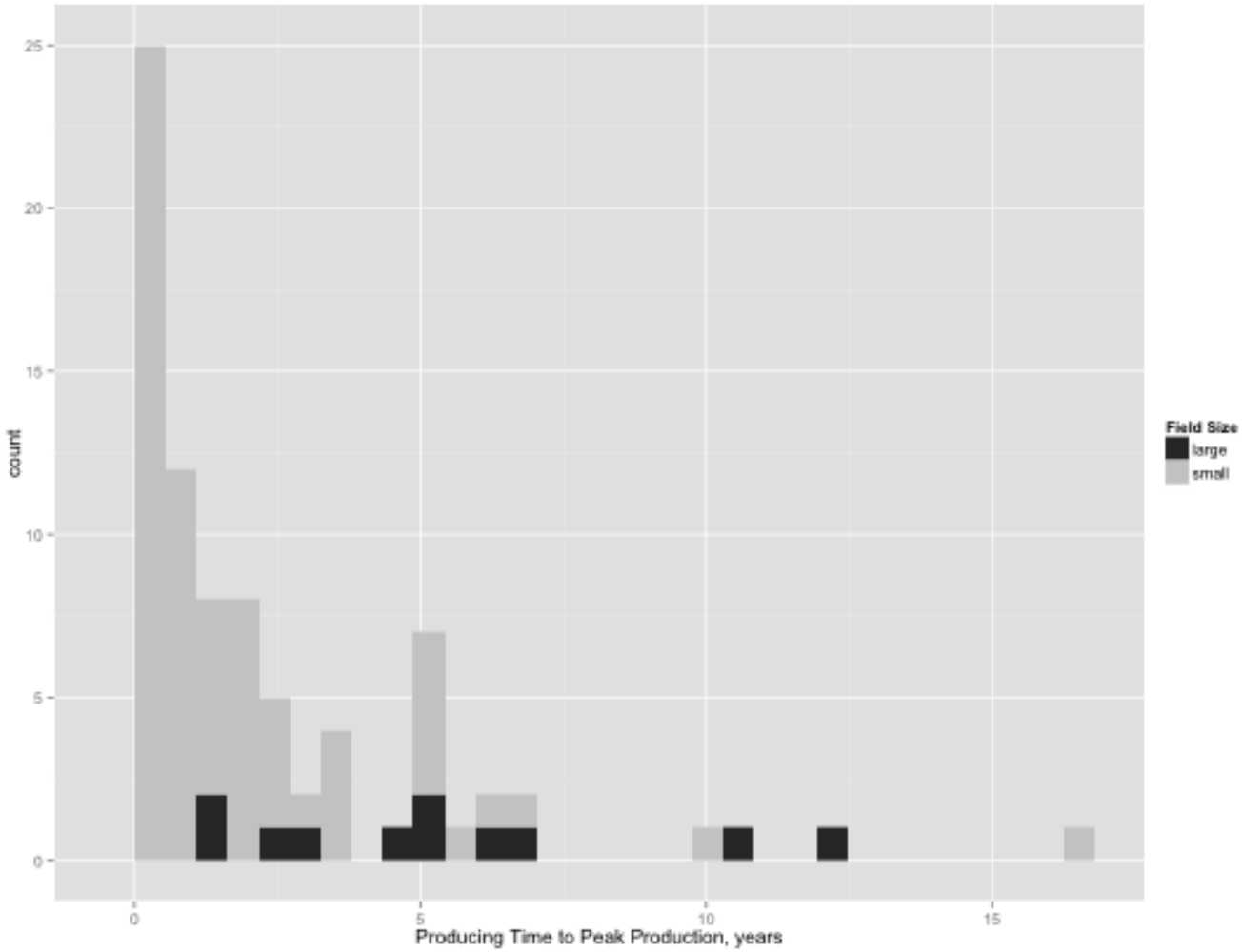
$$J_{22} f = \frac{\partial^2 f}{\partial x_1^2}^2 + \frac{\partial^2 f}{\partial x_1 x_2}^2 + \frac{\partial^2 f}{\partial x_2^2}^2 dx_1 dx_2 \tag{7}$$

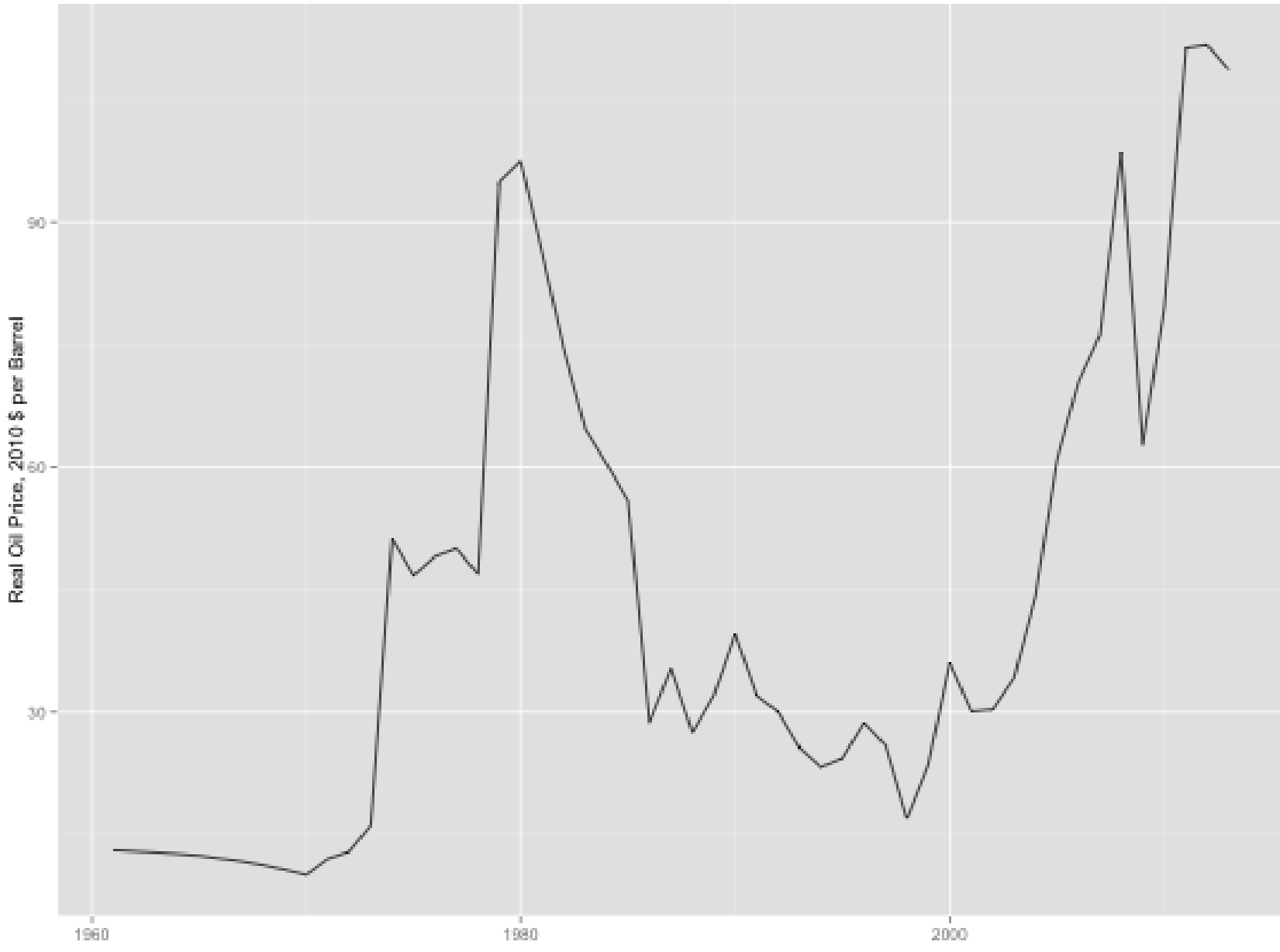
# Build-out Phase



# Depletion Phase




25
20
15
10
5
0
count
0
5
10
15
Producing Time to Peak Production, years
Field Size
large
small


Real Oil Price, 2010 $ per Barrel
90
60
30
1960
1980
2000

## Monte-Carlo Simulation Sudo-code

```
>Generate X fields with size
 from exponential-normal distribution
>Generate random starting year for each field
>Generate logistic cumulative production profile
```

In loop:

>Create production profiles from derivative of logistic function, price component and stochastic component

>Regress ‘‘fake’’ data with GLM and GAM model

>Store point estimates

$$cumProd = \frac{size}{1 + exp(\frac{-prodTime_t}{3})} \tag{8}$$

$$log(production) = f`(time) + beta * log(price) + epsilon$$

$$
\begin{aligned}
prod_t &= poly(prod\_time_t) + field\_size_i \\
prod_t &= s(prod\_time, field\_size_i) + \beta price_t
\end{aligned}
\tag{9}
$$

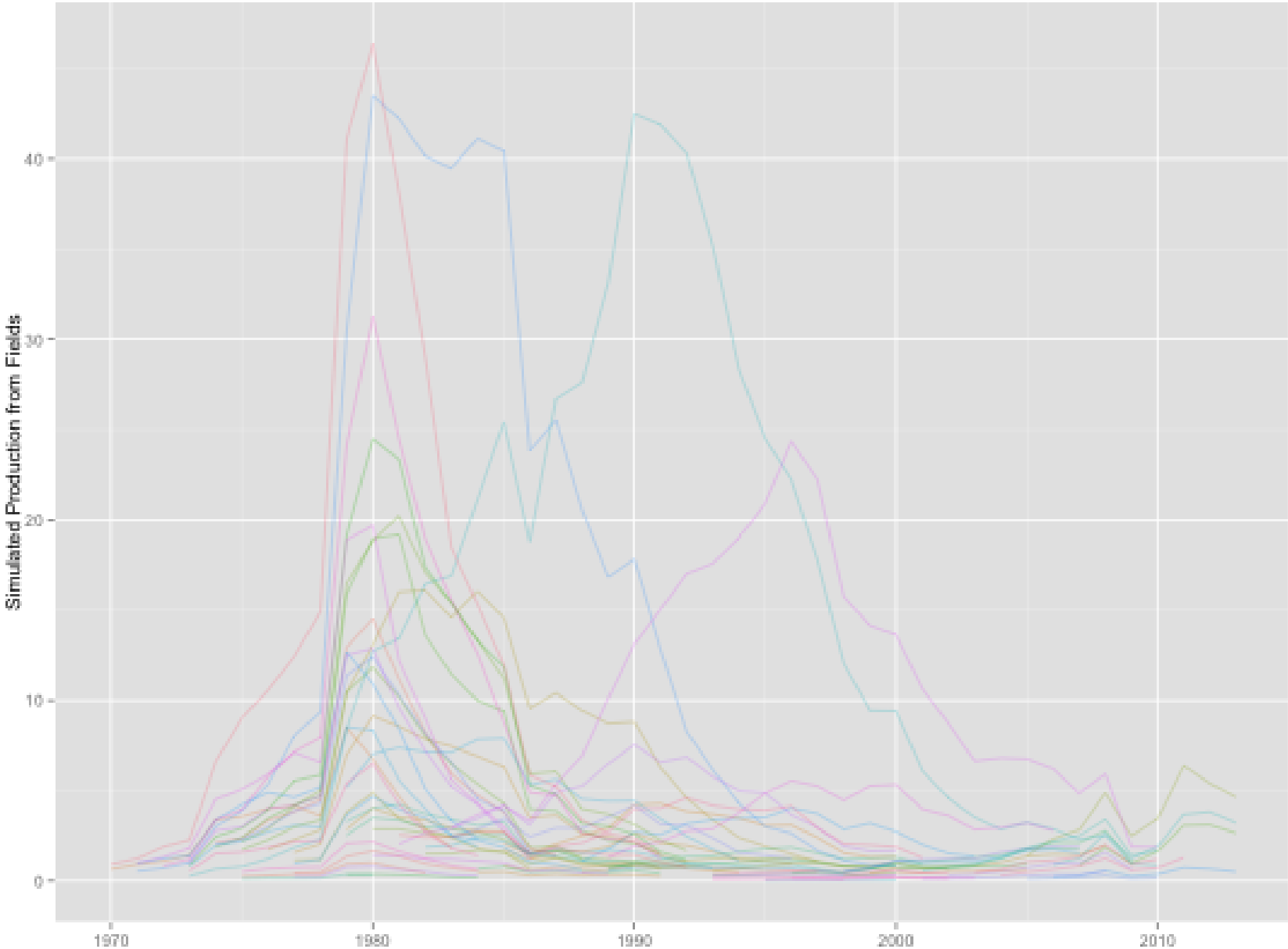



Figure : Simulated production of 77 oil fields

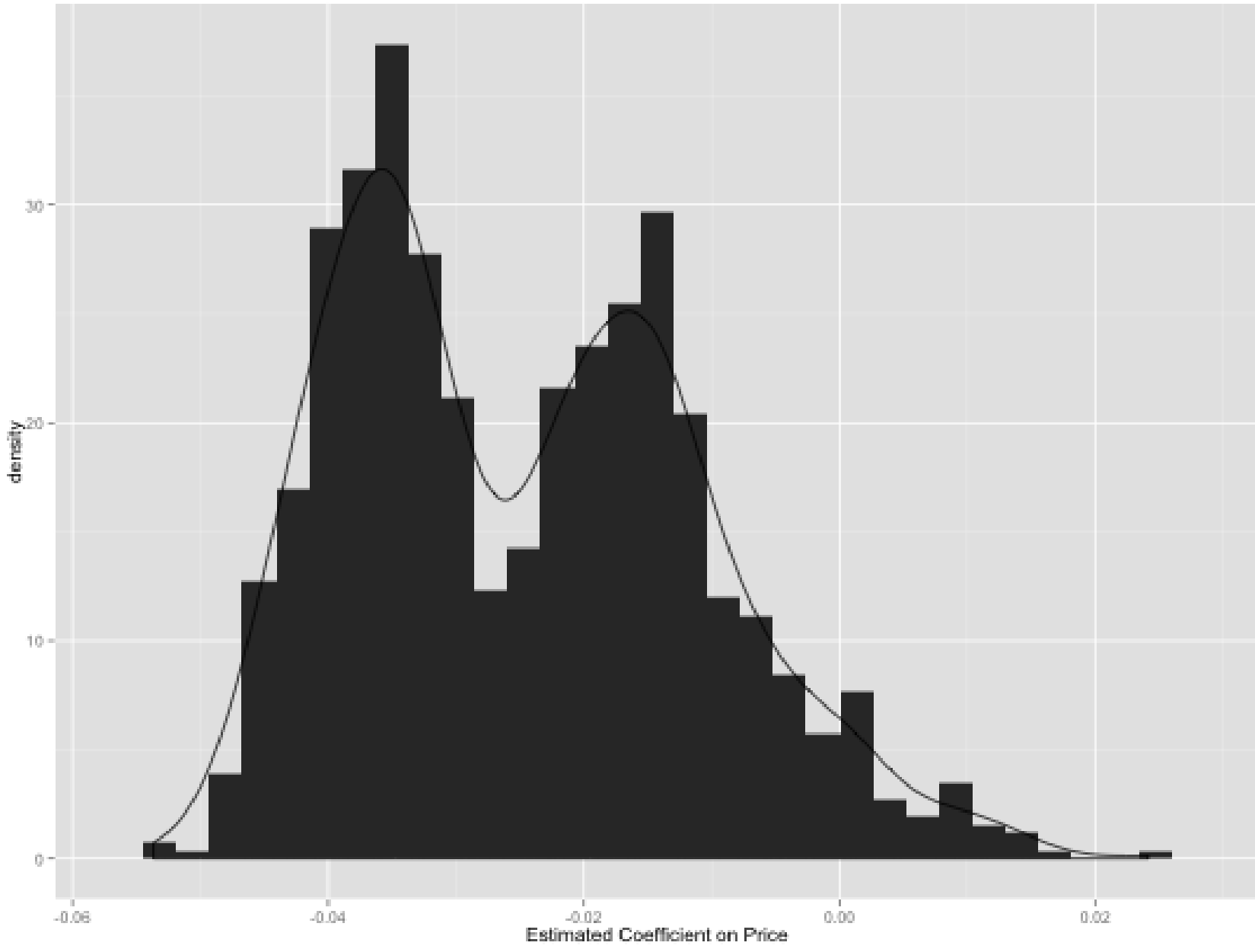



Figure : Estimated coefficients on price from linear model from Monte Carlo Experiment

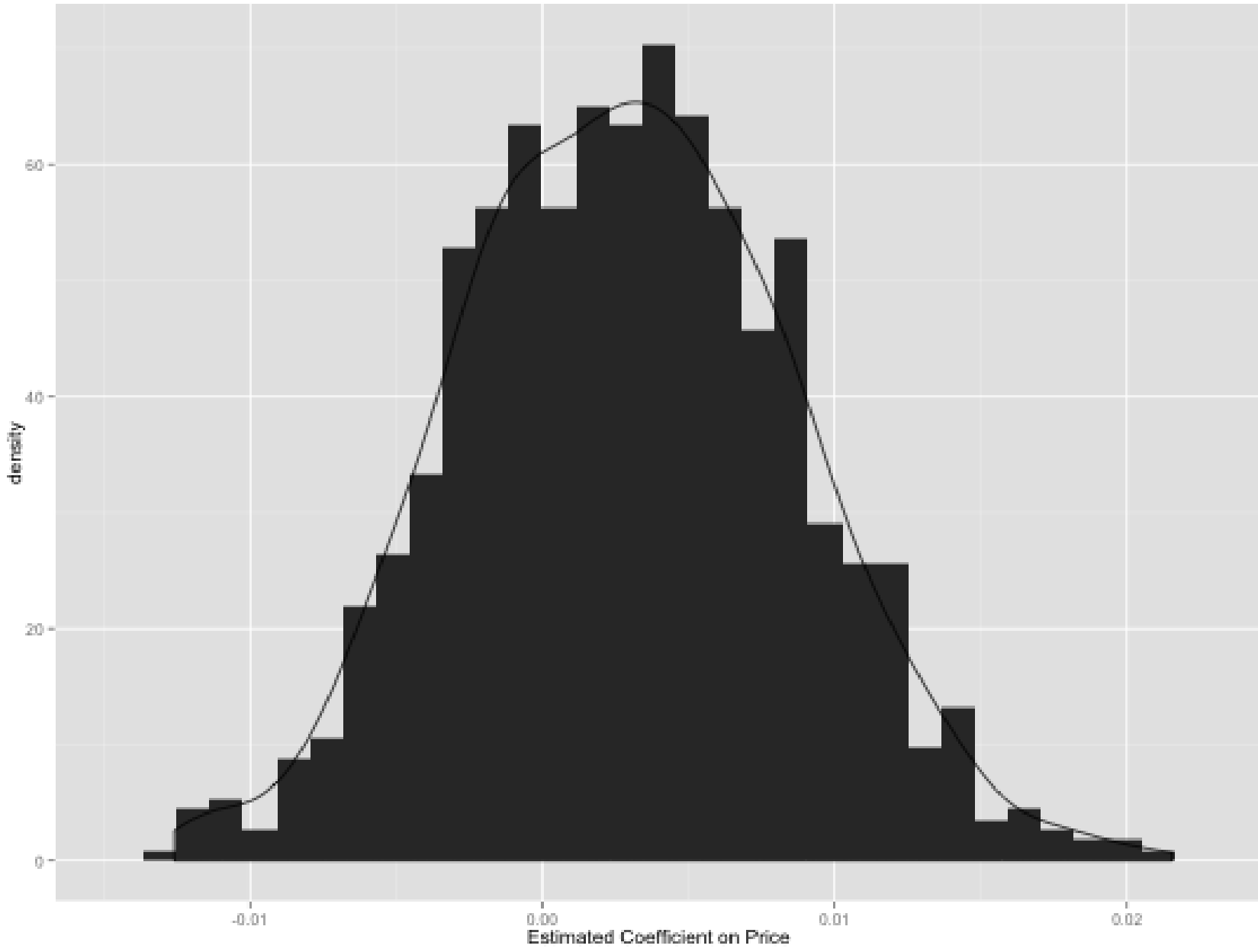
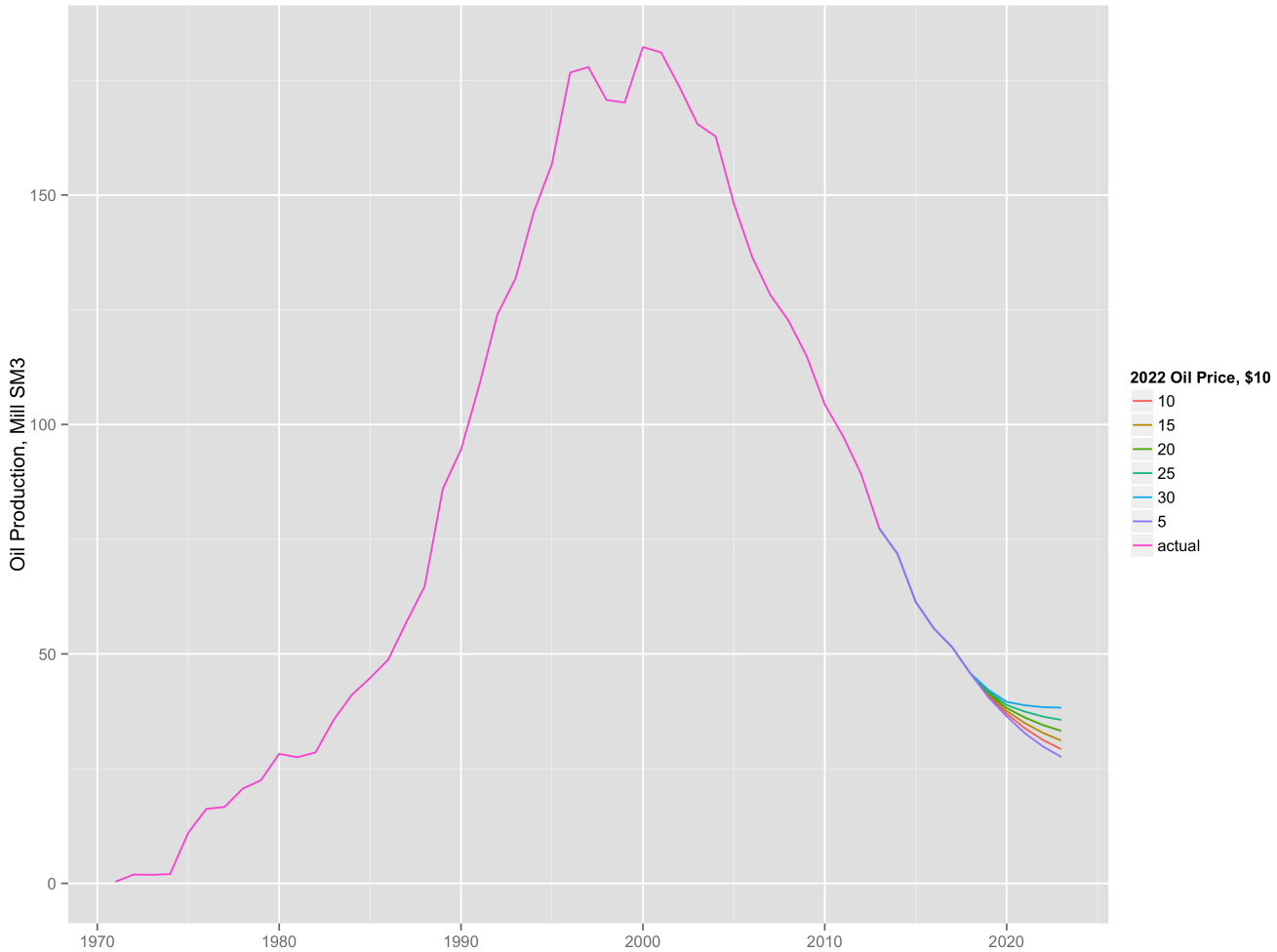



Figure : Estimated coefficients on price from GAM model from Monte Carlo Experiment


Oil Production, Mill SM3
150
100
50
0
1970
1980
1990
2000
2010
2020
2022 Oil Price, $10
10
15
20
25
30
5
actual

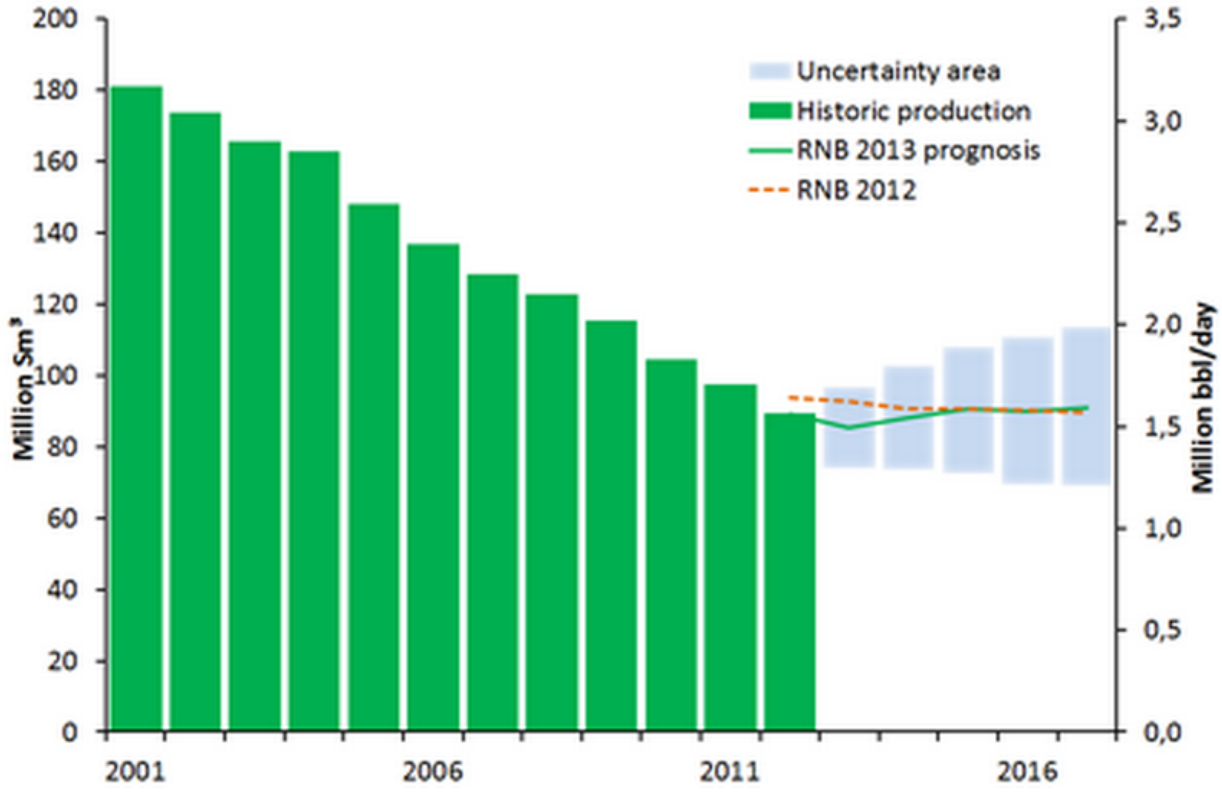



***Figure 3.*** *Uncertainty in future oil production.*

Criticisms

- Ignores significant technical changes in the oil industry

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- Estimate of field size itself is affected by price

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- Time at which production peaks, as measured from the start of production, is likely affected by price as well

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- Ignores significant technical changes in the oil industry
- Field size itself is affected by price
- Time at which production peaks, as measured from the start of production, is likely affected by price as well
- Costs in industry are correlated with oil price

johannes.mauritzen@nhh.no

jmaurit.github.io#oil_prices