# Do financial markets have anything to tell us about the design and management of real assets? Using end-of-life oil field management as an example

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# Consider the following

You are in an E&P organisation that has been operating primarily in the Canadian western sedimentary basin, and are part of a team looking at prospects off the west coast of Africa.

As part of the analysis, your colleagues suggest that, without further study, you should approximate the well productivity in any of these prospects to be the average (weighted by production) of all the wells in which your corporation has an interest.

Would you agree with this course of action?

# Outline

A basic set of questions

Some examples

Summary of some insights from financial markets

The Banff taxonomy of valuation methods and its uses
- Evolution of valuation in industry
- Developments in financial markets
- Where industry might go

An example analysed:  Managing a mature field

Strategy formation and asset valuation

Organisational issues and management of change

Some dead ends

Some concluding remarks

# The basic questions

Can organisations in the mining and upstream petroleum industries improve their asset design and management decision-making process?

If so, is there a role in this for the use of "improved" methods to estimate real asset values?

If so, are there insights to be had from developments in financial markets about how better to estimate real asset values?

If so, is it worthwhile to consider changing valuation processes from those currently in use to gain these insights?

If so, how can this be done with most benefit at least cost?

# The role of asset valuation in making decisions about assets

Define the decision alternatives to be considered

Determine the incremental cash-flows
resulting from each alternative

**Estimate the incremental value of**
**the claim to these incremental cash-flows**

Use as input into making decision

# Value and improved decision-making

Asset value is the asset sale price as it would be in a "deep" (many buyers and sellers) asset market

An improved decision-making process
in a widely-owned corporation
is more likely to produce decisions
about asset design and management
that cause the value, so defined,
of the corporate assets to be as large as possible

# Why cash-flow value is important

Managers of a publicly-held corporation
have a fiduciary responsibility
to maximise the value, so defined,
of the assets of the corporation

Want to determine the effect of any given decision
on the value of the overall set of corporate assets

# Framing
# a useful and manageable analysis

Asset level decisions take place in a corporate setting:
Value depends on that setting

Some corporate effects relatively easy to model:
Joint infrastructure, taxes, informational externalities

For some, no good overall quantitative understanding:
Risk management, financial distress, organisational capital

Asset value estimated as well as possible
is a good starting place

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# Some examples

Managing exploration and appraisal programmes
When is enough enough: Managing the shift from appraisal to production
The facilities capacity decision
Managing the cost profile
Managing the production profile
Managing an asset near the end of its life
Managing a multi-part resource
The value of taxes and other contractual relationships
Creating a strategy for managing GHG emissions
Determining a reservation bid in a complex auction

# An oil field near the end of its life

Production:  5K bbl per day, declining 25% per year

Water: 70% of fluids, proportion increasing  8% per year

Costs:

| | |
|---|---|
| Fixed | $50K per month |
| Lifting | $3.75 per bbl fluids |
| Transport | $1.00 per bbl oil |
| Processing | $2.50 per bbl water |
| Closure | $1500K |

Taxes:  33% of income   all costs expensed

All cash flow booked monthly

# Decisions

Choose not to intervene or to undertake
one of 4 possible interventions to reduce fluids

Choose month of closure

| | | | % Reduction | | Annual rate of change | |
|---|---|---|---|---|---|---|
| # | Time (Mo) | Cost ($K) | Water | Oil | Water (% Inc) | Oil (% Dec) |
| 1 | 4 | 8000 | 10 | 5 | 10 | 30 |
| 2 | 4 | 15000 | 20 | 10 | 12 | 30 |
| 3 | 8 | 8000 | 12 | 5 | 10 | 30 |
| 4 | 8 | 15000 | 22 | 10 | 12 | 30 |

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# Insights from financial markets

More asset cash-flow uncertainty
=> greater effect on asset value

More correlation with overall economic uncertainties
=> greater effect, with opposite sign

Complex assets can be viewed as (possibly dynamic) combinations of simpler assets

Can determine the value of complex assets in terms of the simpler asset valuations

Doing this need not result in a loss of consistency and central control of valuation, quite the contrary

# Insights from financial markets: Long-term market equilibrium

In markets with long-term equilibrium forces:

- Total price uncertainty increases more slowly in the long term than in the short term
- Constant discounting undervalues long-term cash-flows that increase with such long-term prices

Current methods biased against long-term production:

- Overvalue short-lived assets
- Suggest higher production capacity than optimal

Methods used in financial markets to estimate value do not have this bias

## Insights from financial markets: Operating, contractual and fiscal leverage

If costs are less risky than revenues:

- Asset uncertainty greater than uncertainty in both revenues and costs (operating leverage)

- Appropriate asset discount rates usually undervalue both revenues and costs

- Single rate DCF overvalues more levered assets

Current methods biased against investing in capital that enhances future revenue or reduces future costs

Current methods biased against risk reducing contractual or fiscal terms

Methods used in financial markets to estimate value do not have this bias

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The example laid out

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## SPE valuation workshop Banff Sept 2003

Confusion about

conceptual underpinnings,
relationships,
best practice
of different methods to estimate value

SPE used for pre-competitive investigations

Banff 2003 workshop on "Next steps in valuation"

## Some Banff workshop conclusions

Financial market value of individual assets
useful inputs into decision making process

Banff taxonomy of valuation methods
a useful organising tool

Organisations should explore methods with:

Dynamic quantitative models of uncertainty
Risk adjustment at sources of uncertainty

Takes time to assimilate ideas involved

More and longer courses needed

# The Workshop Committee

David Laughton (David Laughton Consulting, University of Alberta)
Steve Begg (University of Adelaide, 2000 forum co-chair,
formerly Landmark, BP)
John Campbell, Jr. (Decisions!Decisions!, 2000 forum co-chair)
Ellen Coopersmith (DecisionFrameworks, formerly Conoco)
Mike Grandin (Elk Valley Coal, Encana, formerly Sceptre)
Frank Koch (ChevronTexaco)
Steve Letros (Shell Canada)
Bob Ligon (Unocal, 2002 forum chair)
Morten Lund (Statoil)
John Parsons (Charles River Associates)
Gardner Walkup, Jr. (Strategic Decisions Group, formerly Chevron)

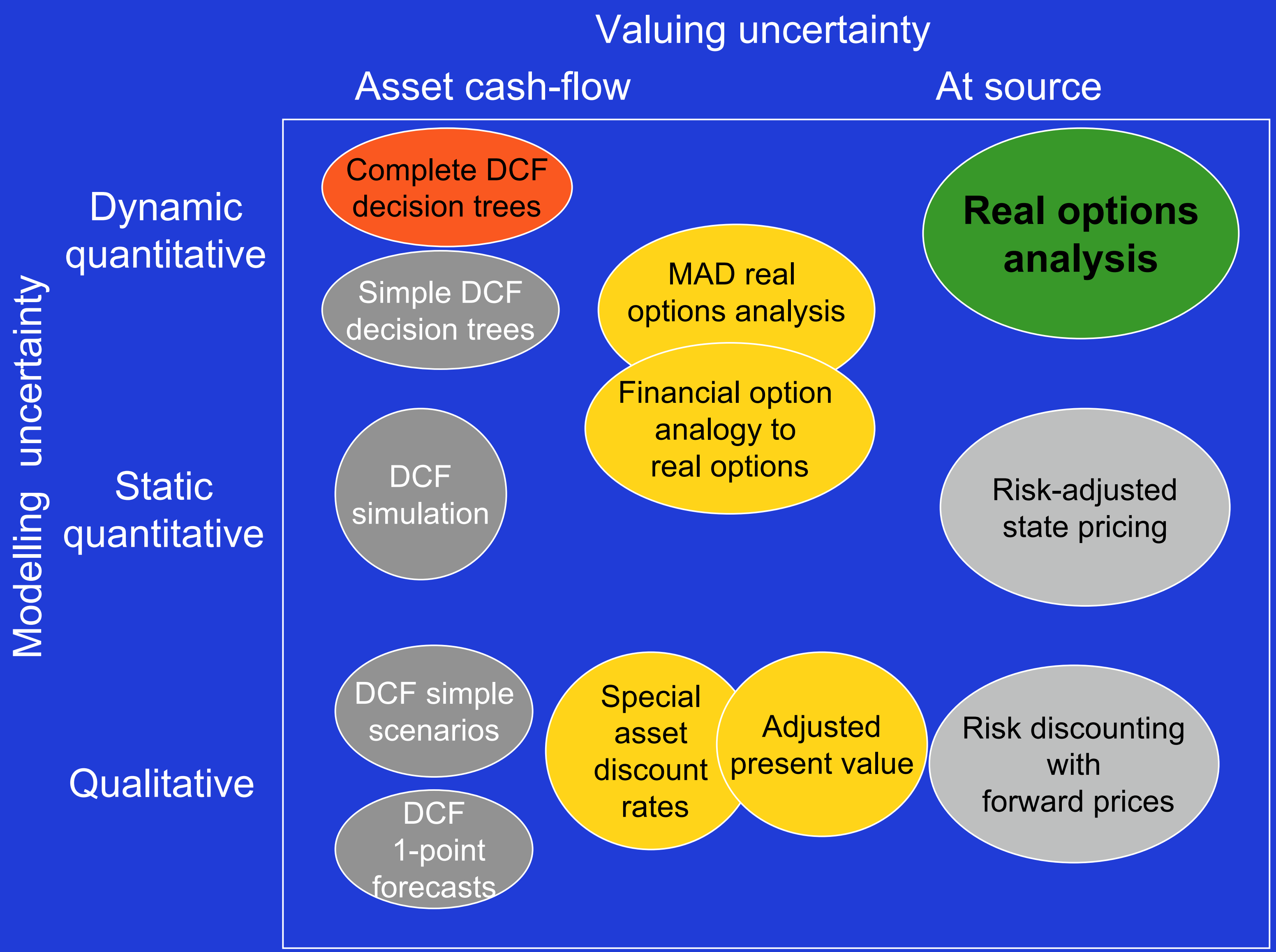
# Banff taxonomy axes

Valuing uncertainty

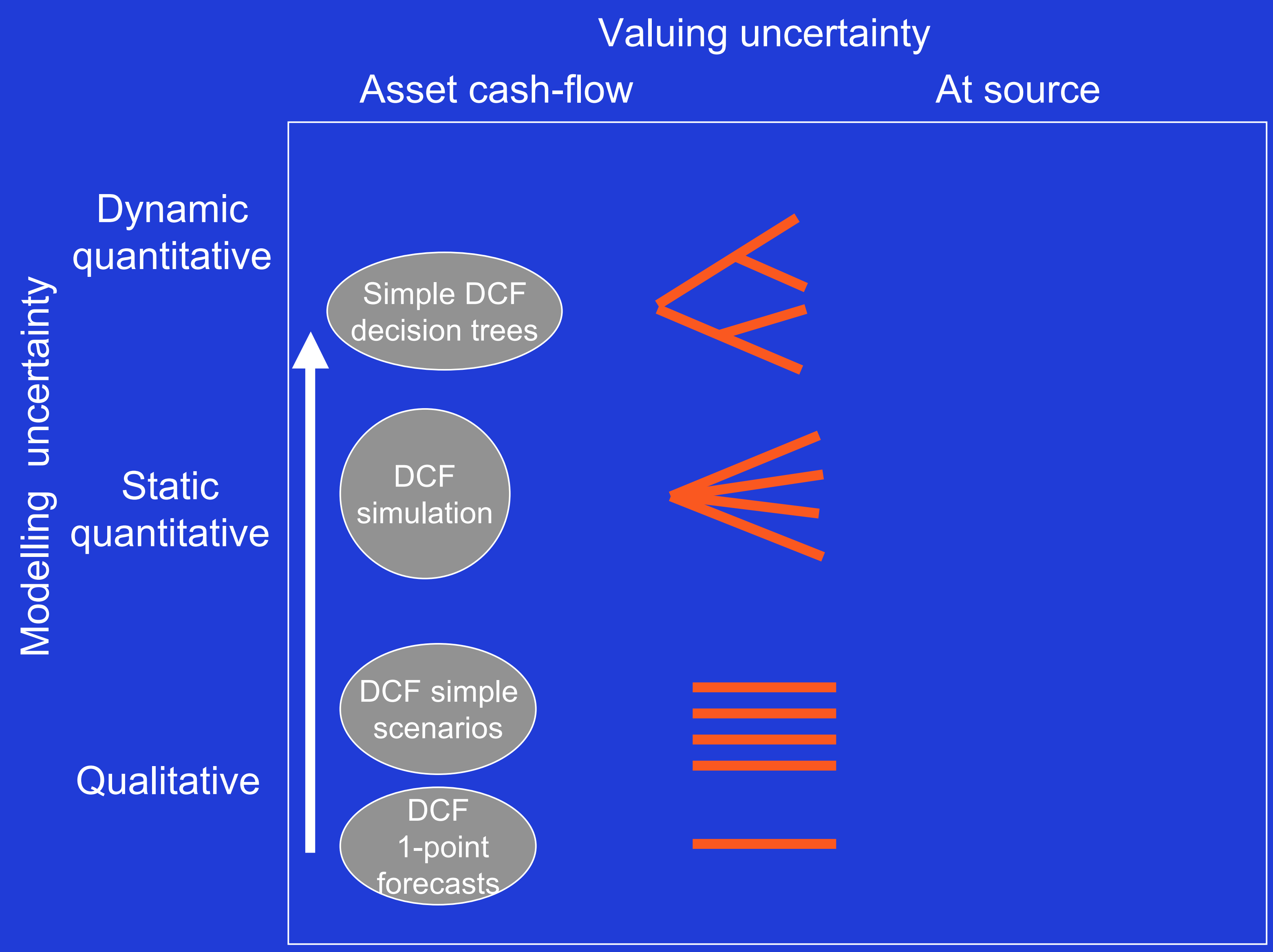
| | Asset cash-flow | At source |
|---|---|---|
| Dynamic quantitative | | |
| Static quantitative | | |
| Qualitative | | |

Modelling uncertainty

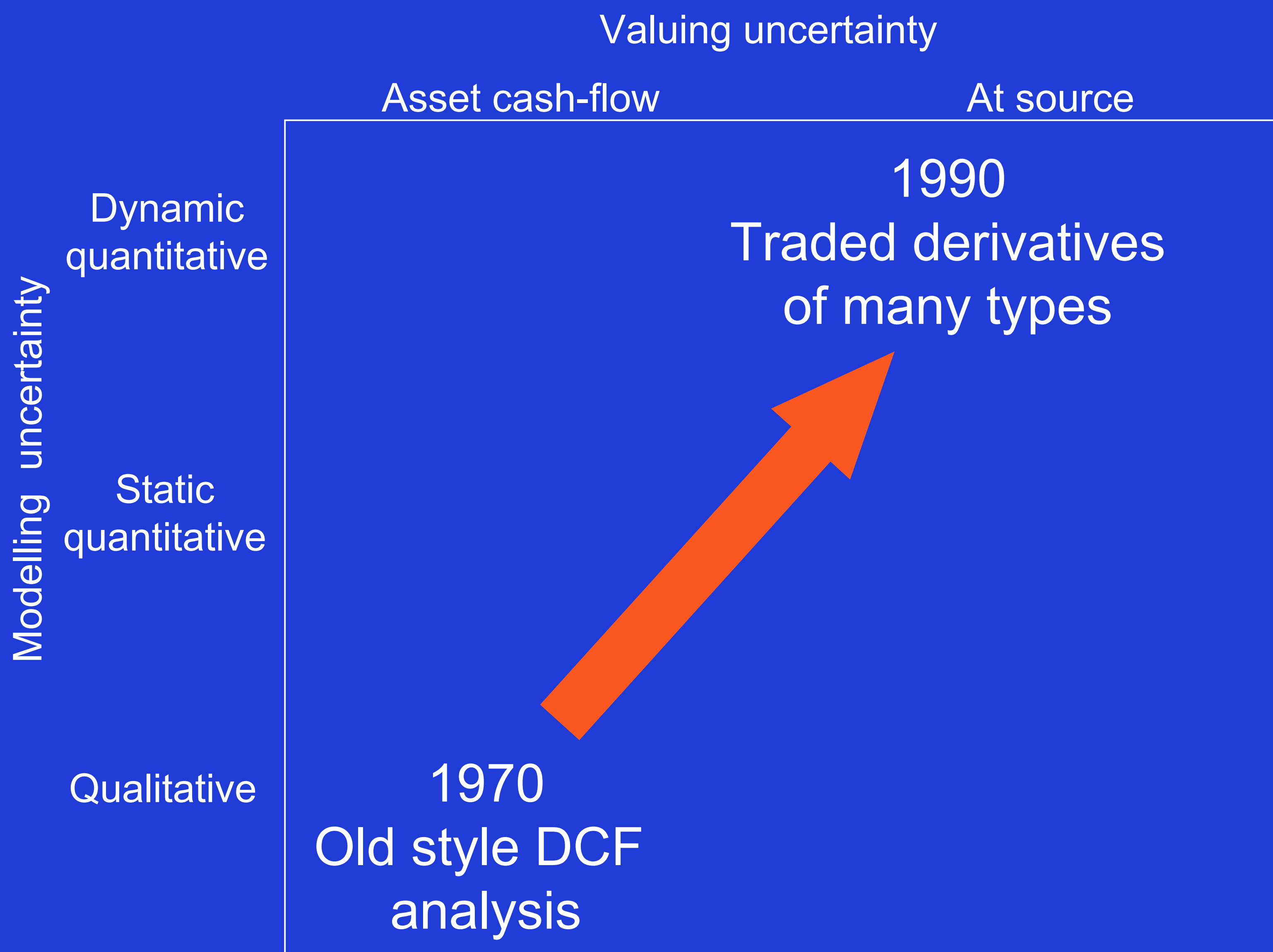
# Banff taxonomy of real asset valuation



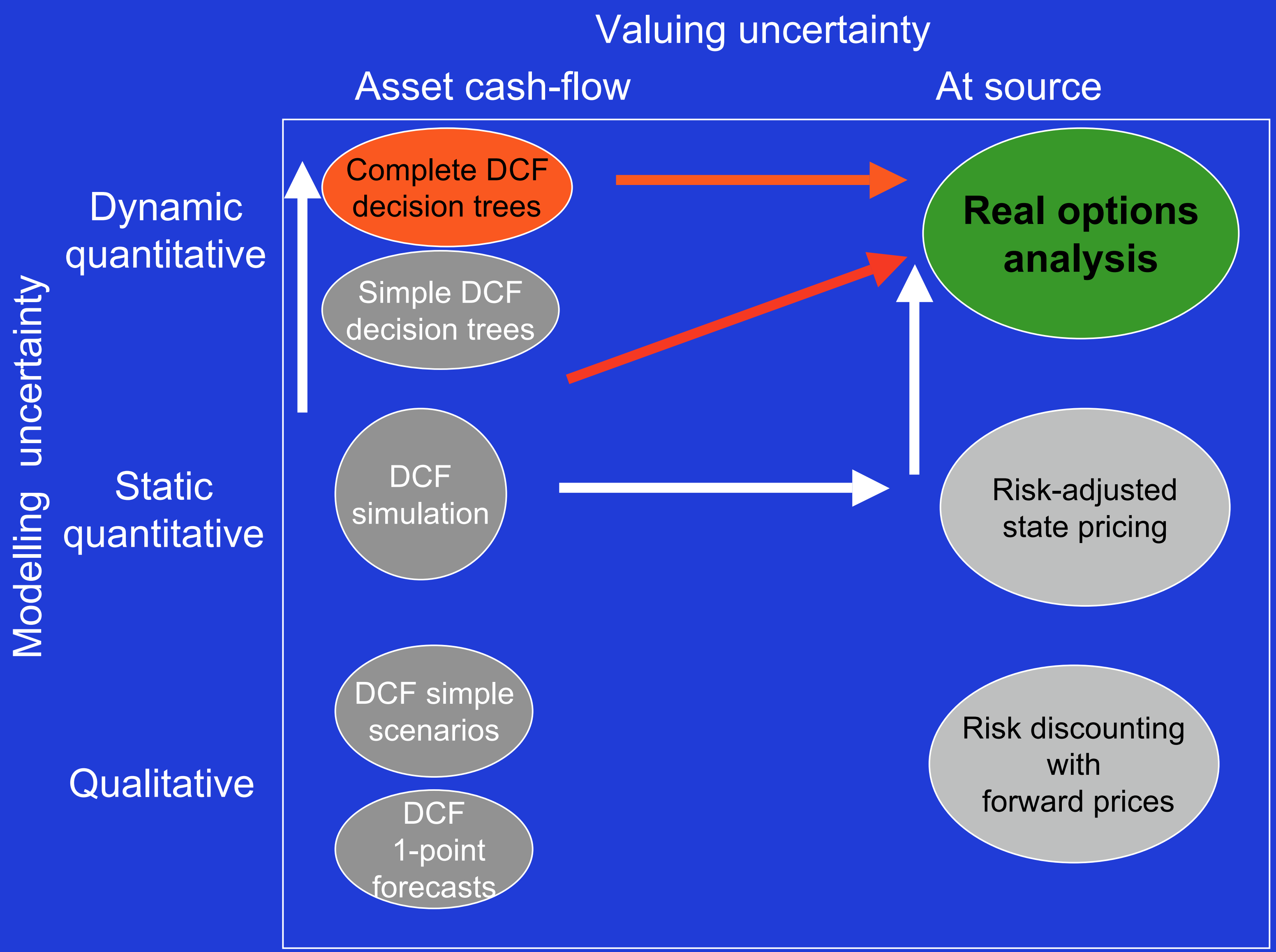
# Evolution of asset valuation in industry



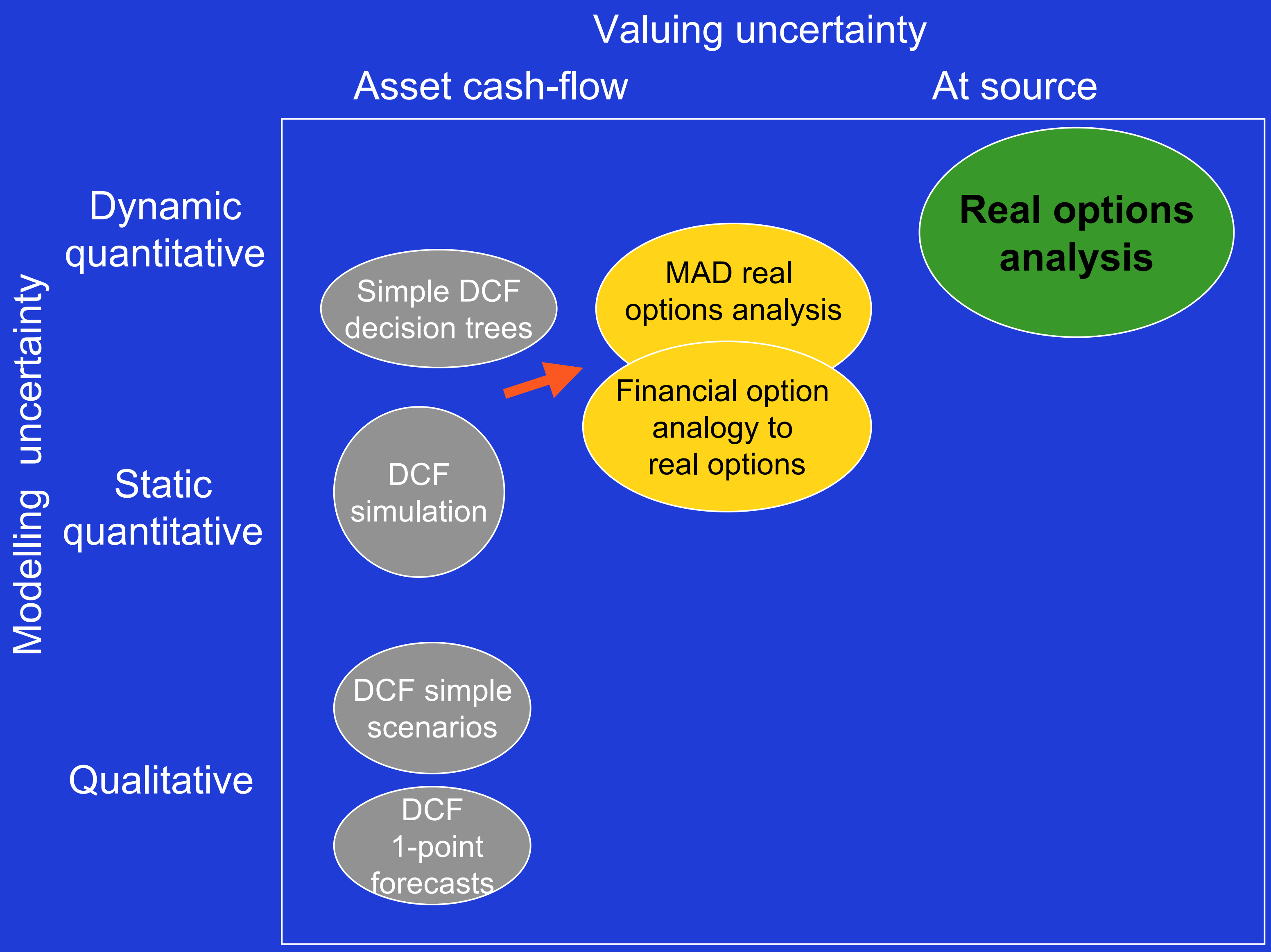
# Evolution of valuation in financial markets



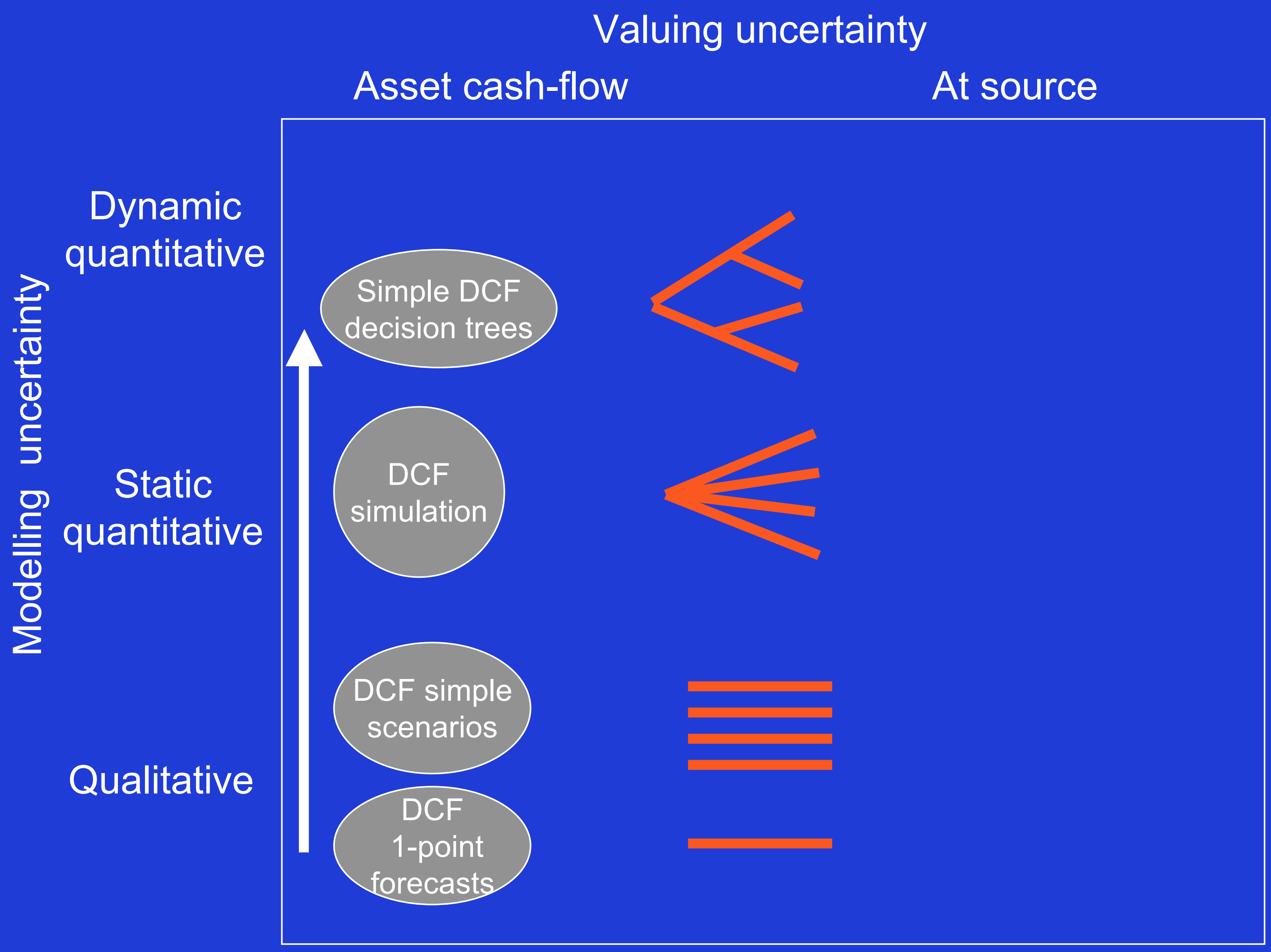
# Future possibilities for industry



# Different approaches to "real options"



# Evolution of asset valuation in industry



# Evolution of asset valuation in industry

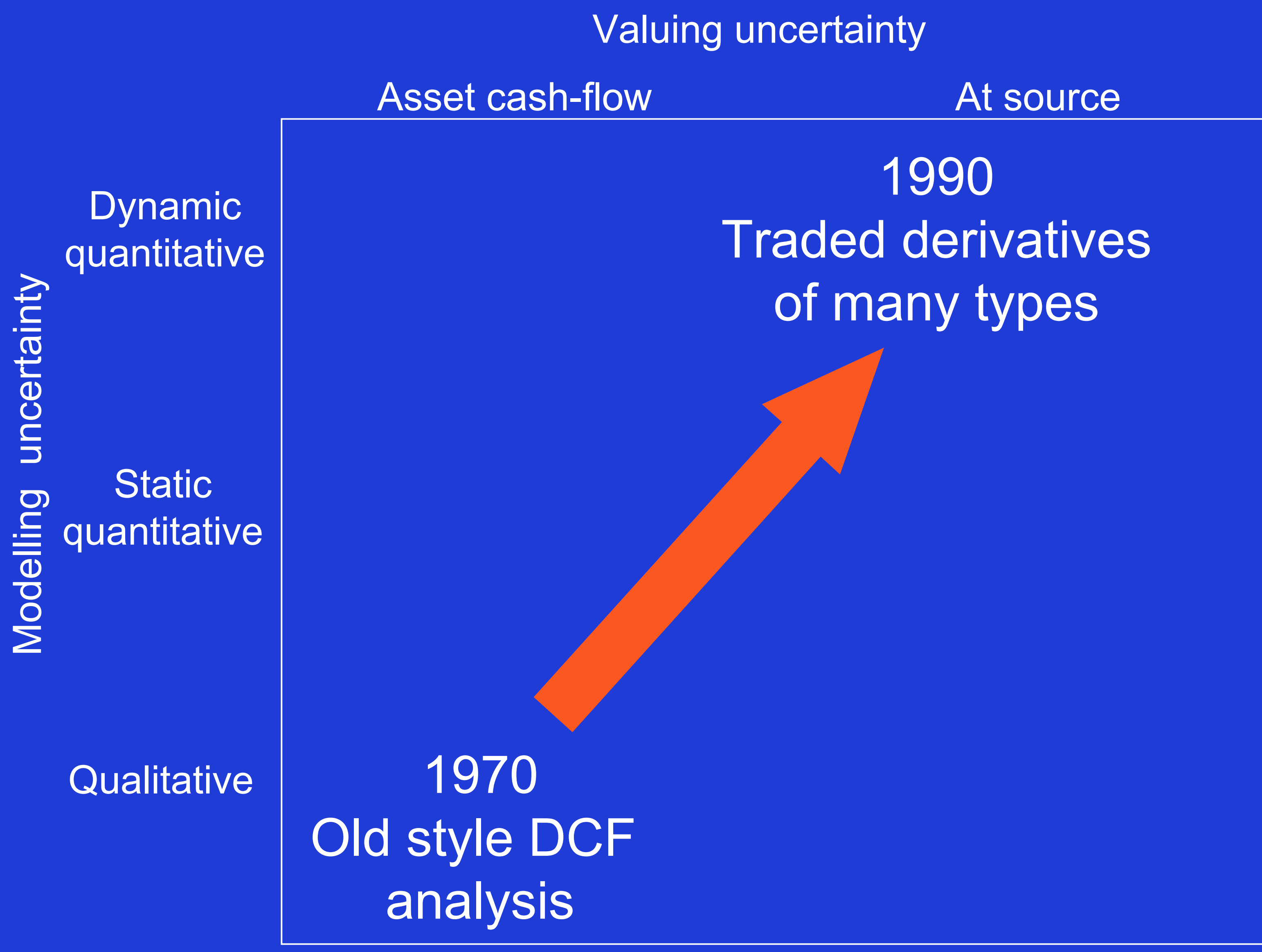
Move up the left side of the taxonomy

DCF (discounted cash-flow) valuation of
cash-flow streams based on
a single discount rate either for all assets
or large groups of assets

Move from simple qualitative models of uncertainty
to static quantitative models to support simulation
to dynamic quantitative models to support
decision tree analysis

Decision tree analysis focussed on resolving
uncertainty in geological variables
early in asset life cycle

# Evolution of valuation in financial markets



## Black-Scholes-Merton replication: An example

An asset with one cash-flow 3 months from now

Amount = 1 if Alcan common share price then is between $20 and $21

0 otherwise

Valuation based on:

A dynamic model of Alcan share price movements

**The Law of One Price**:

Transaction costs in financial markets low enough => assets with same payoffs have same price

# Black-Scholes-Merton valuation: An example

Begin with a portfolio of determined amounts of
Alcan shares and a risk-free asset

Trade over time in response to Alcan price movements
so that, no matter what the Alcan price,
portfolio value at time of the cash-flow
= cash-flow amount

By **the Law of One Price**,
value of cash-flow claim at any time
= portfolio value at that time

## The key innovations in financial market asset valuation

Begun by Black, Scholes and Merton in 1970
in their analysis of simple stock options

Key innovations:
**Dynamic quantitative models of uncertainty**
**Valuation of effects of uncertainty at source**
**with creative use of the Law of One Price**
**(same asset cash-flows => same asset price)**

Contrary to popular belief,
**optionality** **NOT** the important issue,
**valuing complex assets as (dynamic)**
**combinations of simpler assets** the main issue

# Aside on The Law of One Price

True if financial markets transactions costs or barriers low enough

Implies:

0) **Use of comparables**

1) **Additivity of value**

Divide asset into parts that can be valued, value the parts and add the values

2) **Separating** effects of **uncertainty and time**

Cash-flow claim value
= cash-flow forward price * time discount factor

3) **Black-Scholes-Merton replication**

4) **Rollover valuation** of multiperiod prices

# Aside on forward contracts and prices

A forward contract is a mutual obligation to exchange
at a fixed future date (**maturity date**)
a defined uncertain amount of cash for a fixed amount.

The fixed amount is called the **forward price**
of the uncertain amount

How does the forward price of an uncertain cash-flow
relate to the current value of the claim to that cash-flow?

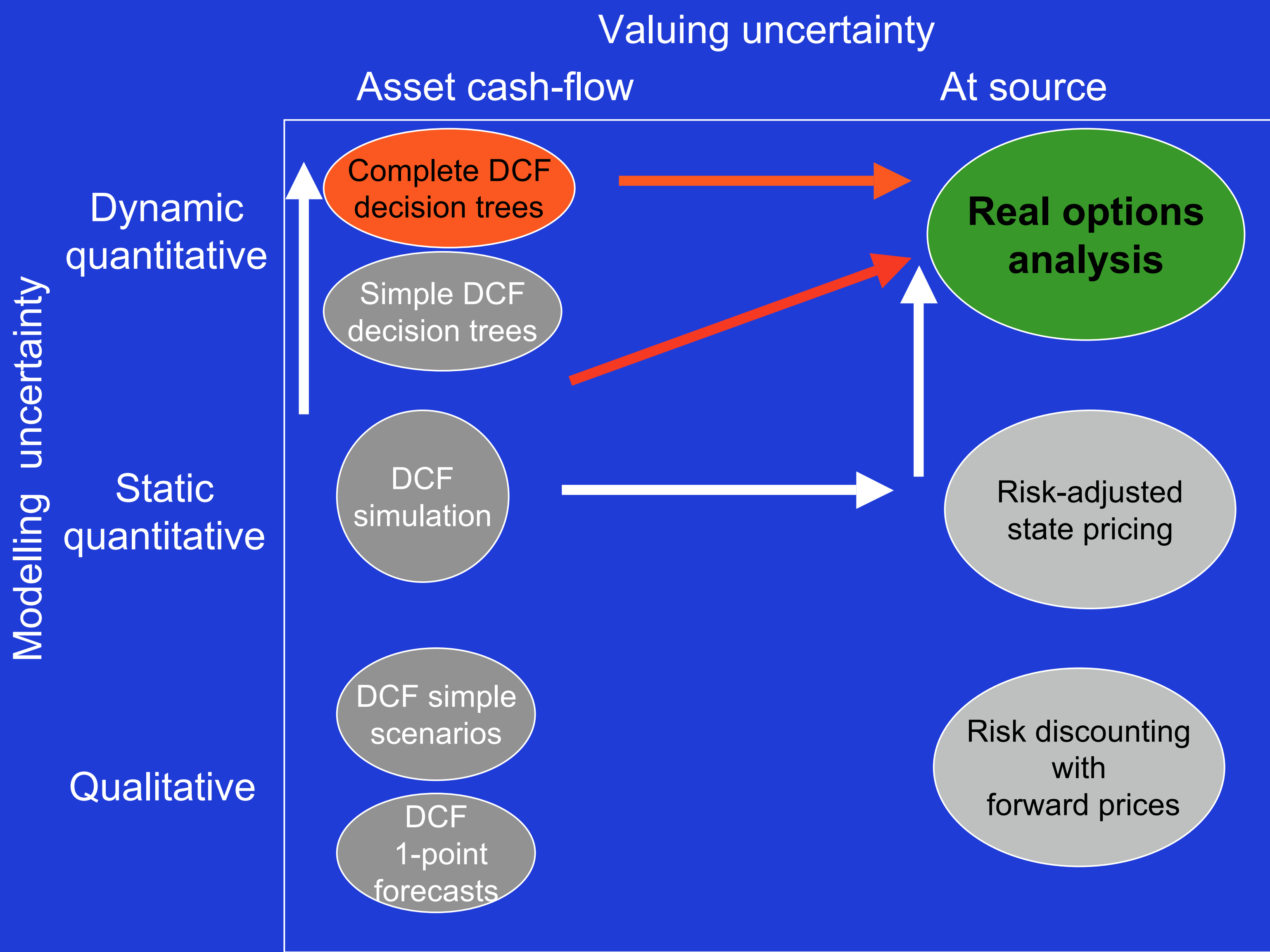
Cash-flow claim value
= cash-flow forward price * time discount factor

# Effects on financial markets

Valuation technology allows unbundling of risks
and permits their market securitisation

Explosion in types and numbers of traded securities:
- FOREX/commodity/interest rate/equity index
  futures and options
- Swaps, options of swaps
- Mortgage backed securities
- Credit derivatives
- Weather derivatives
- Complex project financings

# Future possibilities for industry



## Issues in moving up the vertical axis

Allows analysis of flexibility, its management and value throughout the asset life cycle

Use dynamic scenario models
of all types of dynamic uncertainty (including prices)
throughout the asset life cycle

Moving up => more complex inputs and computations

Like shift from 2-D to 4-D seismic

# Issues in moving up the vertical axis: Modelling and computation

DCF-DTA value of asset

= max over policies p

(sum over scenarios s

(probability$_s$

* sum over times t

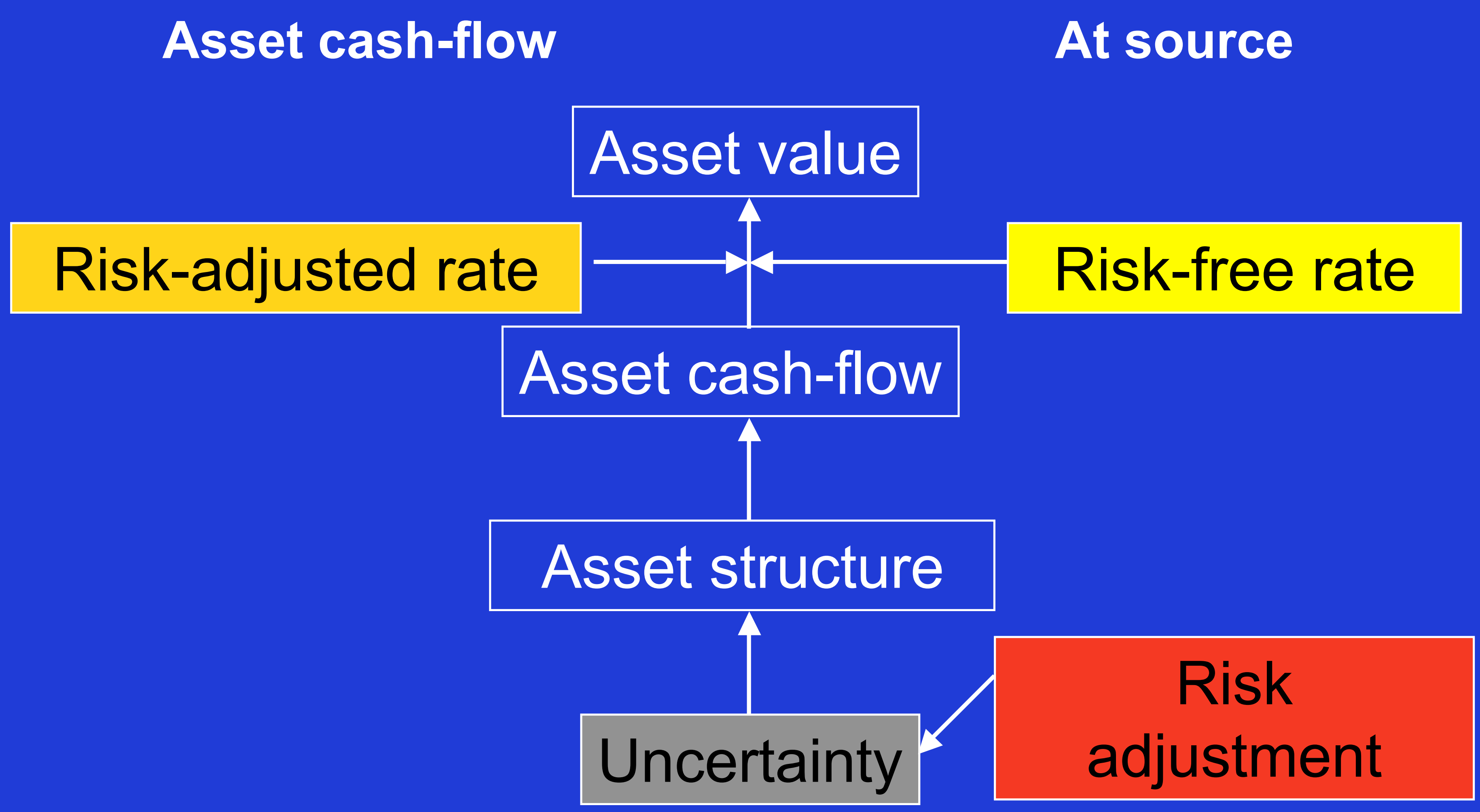
(asset net cashflow $_t$ (p,s)

* corporate risk discount factor $_t$

* time discount factor $_t$)))

More extensive policy search, scenario sum

# Valuing uncertainty



# Issues in moving to the right side: Modelling and computation

ROA value of asset
= max over policies p
(sum over scenarios s
(probability$_s$
* sum over times t
(asset net cashflow $_t$ (p,s)
* scenario risk adjustment $_{s,t}$
* time discount factor $_t$)))

scenario risk adjustment $_{s,t}$
vs. corporate risk discount factor $_t$

# General properties of scenario risk adjustments

Risk-free cash-flows not discounted for risk only if

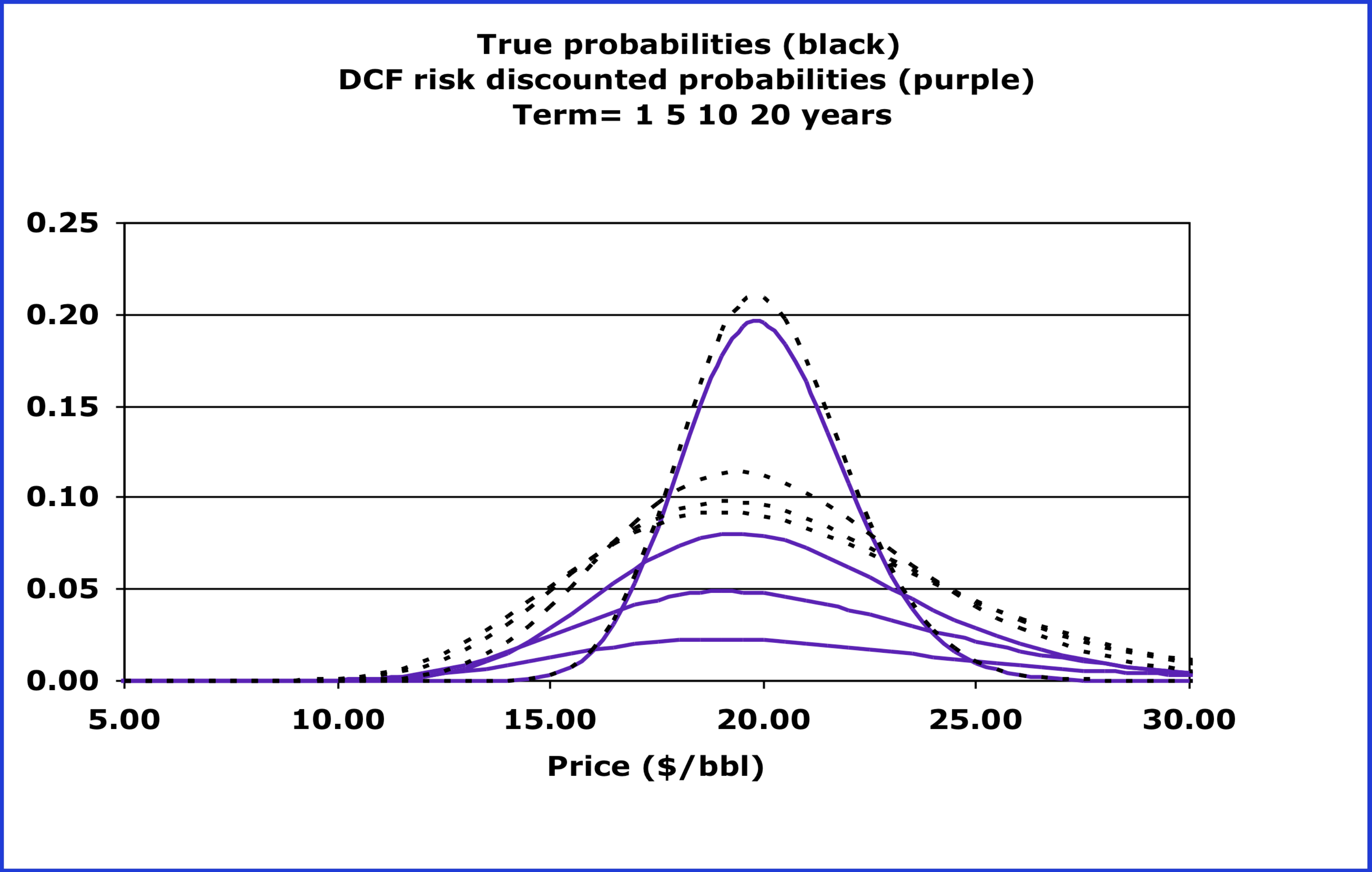
1 = sum over scenarios s
(probability$_s$ * scenario risk adjustment $_{s,t}$)

Risk-adjustment * probability
is a risk-adjusted probability

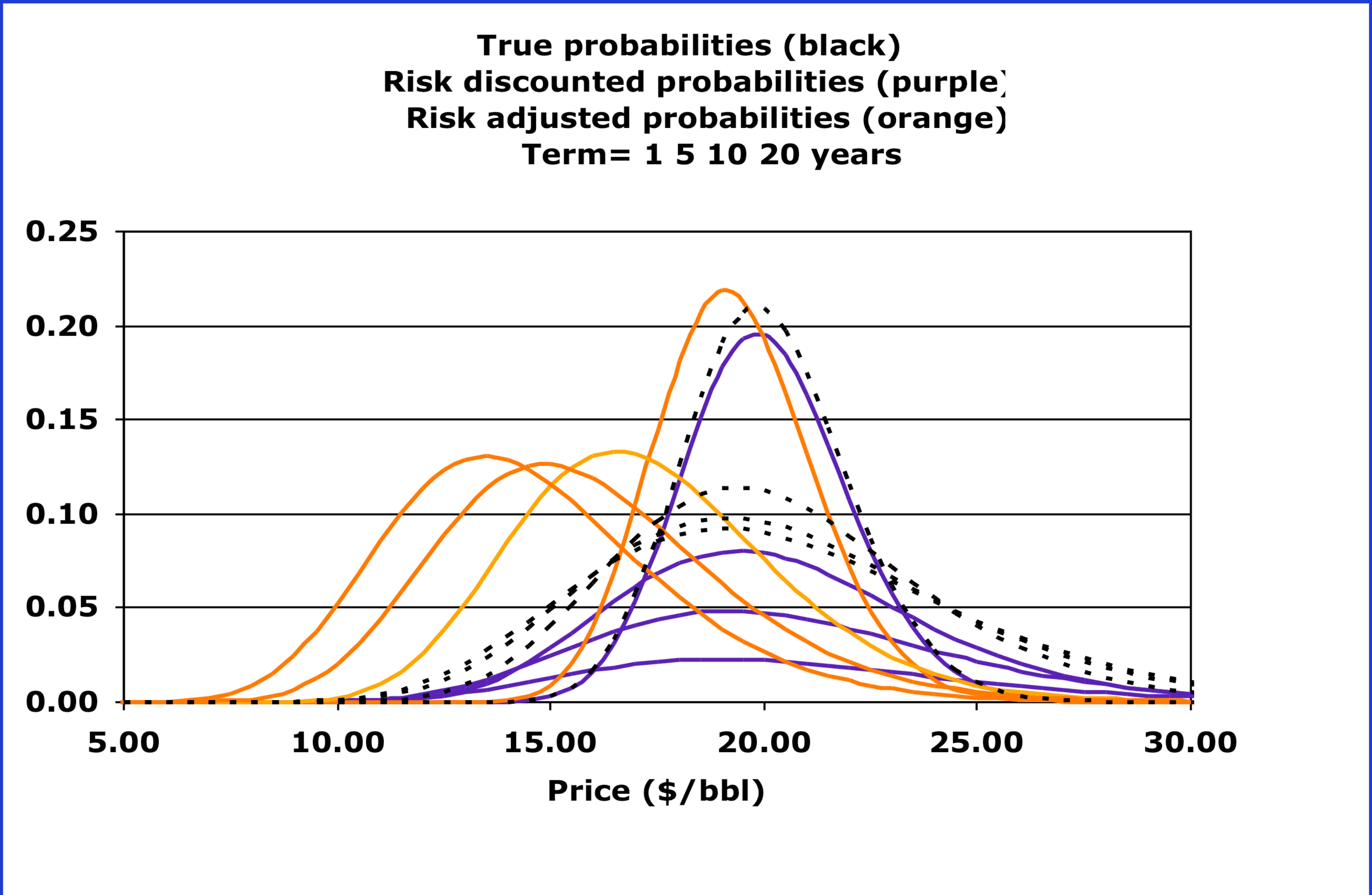
Forward price of a variable realised at time t
= sum over scenarios s
(risk-adjusted probability$_{s,t}$ * variable(s))

which is the time=t risk-adjusted expectation
of the variable

# Simulation and DTA
# Risk discounting oil price scenarios



# Risk discounting vs. adjustment with oil price uncertainty



# Risk discounting vs. adjustment

Risk discounting decreases the weight in the valuation of all scenarios by the same amount at a given time

Risk adjustment shifts the distribution to be centred on the forward prices of variable being considered

If forward price of the variable < its expectation, scenarios with low/high realisations of the variable are given more/less weight

Does this make sense?

Yes, because of risk aversion.

# Risk adjustment and risk aversion

A risk-averse person values cash more/less
when otherwise poor/rich

Prices of cash-flow claims
for cash-flow correlated with the economy
are discounted for risk
because most people are risk averse

If oil forward prices are discounted for risk,
oil prices correlated with the economy
=> People are likely to be poorer/richer
when oil oil prices are low/high
=> Cash-flow claims have higher/lower prices
for cash-flow received when oil prices low/high

## Risk adjustment and discounting: A cash-flow determined by an oil price

If cash-flow increases with the oil price
(e.g., oil-field net cash-flow),
low/high cash-flow scenarios have more/less weight
in valuation than given by their probability
=> Discounting for oil price risk in valuation of cash-flow

If cash-flow decreases with oil price,
markup for oil price risk

If cash-flow does not depend on oil price,
no discounting or markup for oil price risk

# Economy-wide and local variables

Uncertainty in local geological and technical variables not correlated with state of economy

=> No change in risk adjustment due to differences in local variables

Risk adjustments determined only for economy-wide variables

=> Risk adjustments can be determined/controlled centrally

Specialised consulting services exist to determine risk adjustments

# Economy-wide and local variables: Modelling and computation

ROA value of asset

= max over policies p

(sum over local scenarios l

(local scenario $probability_l$

* (sum over economy-wide scenarios e

(economy-wide scenario $probability_e$

* sum over times t

(asset net $cashflow_t$ (p,e,l)

* scenario risk $adjustment_{e,t}$

* time discount $factor_t$)))))

DCF-DTA value same with corporate risk discount $factor_t$

## Issues in moving to the right side

Allows uncertainty sources and asset structure to determine effects of asset risk on asset value

Economy-wide scenario-specific risk adjustments determined using Black-Scholes-Merton (BSM) ideas based on financial market data as much as possible

Methods on the right called **Market-Based Valuation** (MBV)

Moving right => more complex risk adjustments (controlled at centre), but otherwise same calculations

Like using field-specific well productivity in analysis of each field, not average corporate well productivity

# Some issues in moving to the right

Long-term equilibrium

DCF overvalues short-term production:

- Suggests higher production capacity than optimal
- Undervalues long-lived assets

MBV does not

Leverage

DCF overvalues assets with high leverage:

- Suggests less than optimal current investment to enhance future revenue or reduce future costs
- Undervalues leverage reducing contractual or fiscal terms

MBV does not

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# An oil field near the end of its life

Production:  5K bbl per day, declining 25% per year

Water: 70% of fluids, proportion increasing  8% per year

Costs:

| | |
|---|---|
| Fixed | $50K per month |
| Lifting | $3.75 per bbl fluids |
| Transport | $1.00 per bbl oil |
| Processing | $2.50 per bbl water |
| Closure | $1500K |

Taxes:  33% of income   all costs expensed

All cash flow booked monthly

# Decisions

Choose not to intervene or to undertake one of 4 possible interventions to reduce fluids

Choose month of closure

| # | Time (Mo) | Cost ($K) | % Reduction Water | % Reduction Oil | Annual rate of change Water (% Inc) | Annual rate of change Oil (% Dec) |
|---|---|---|---|---|---|---|
| 1 | 4 | 8000 | 10 | 5 | 10 | 30 |
| 2 | 4 | 15000 | 20 | 10 | 12 | 30 |
| 3 | 8 | 8000 | 12 | 5 | 10 | 30 |
| 4 | 8 | 15000 | 22 | 10 | 12 | 30 |

# Cash flows

cash-flow at time t

$$= \text{after-tax production}_t * \text{oil price}_t - \text{after-tax cost}_t$$

$\text{After-tax production}_t = (1 - \text{tax rate}) * \text{production}_t$

$\text{After-tax cost}_t = (1 - \text{tax rate}) * \text{cost}_t$

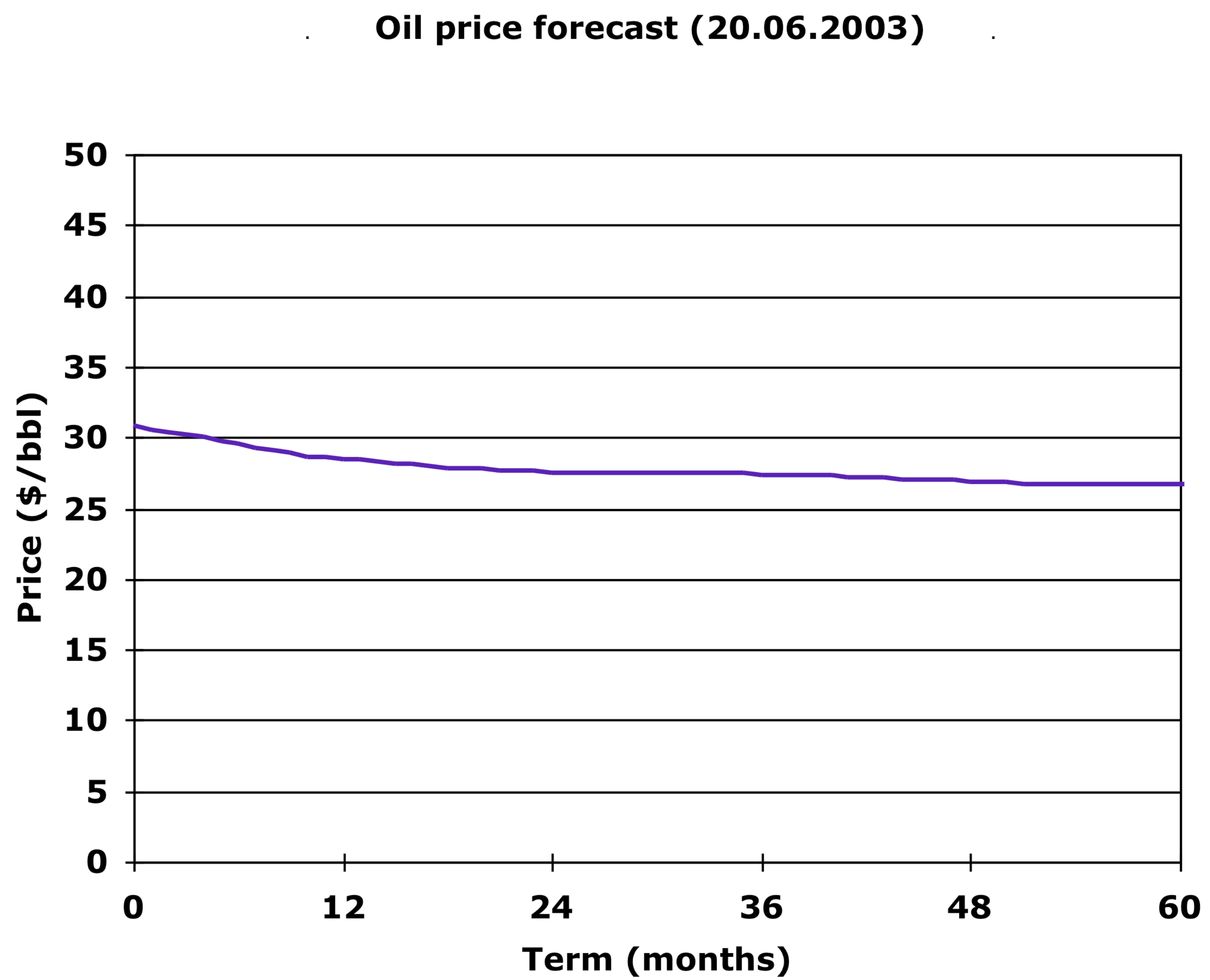
Only uncertainty is in oil prices

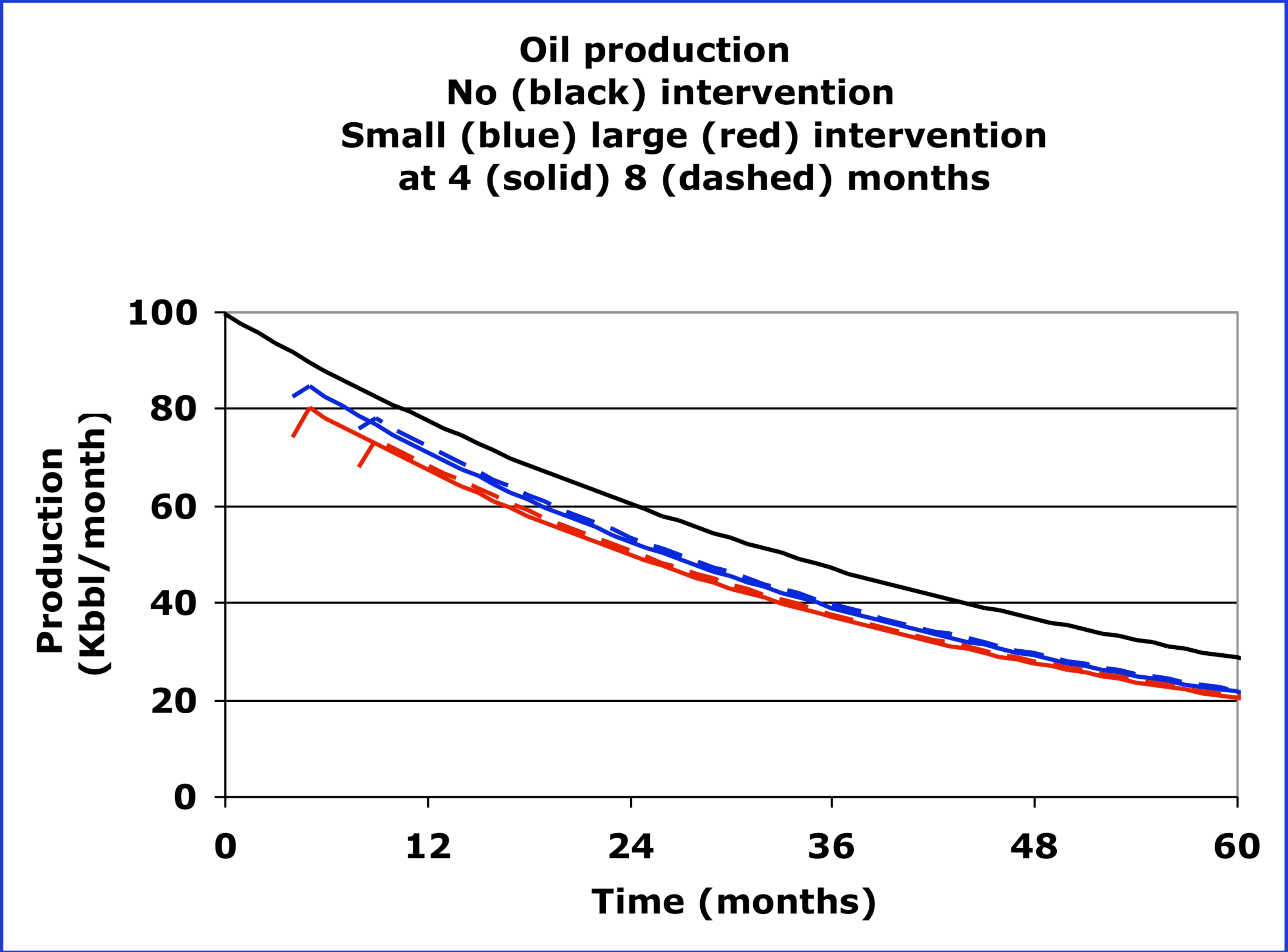
# DCF analysis

DCF value of the oil field

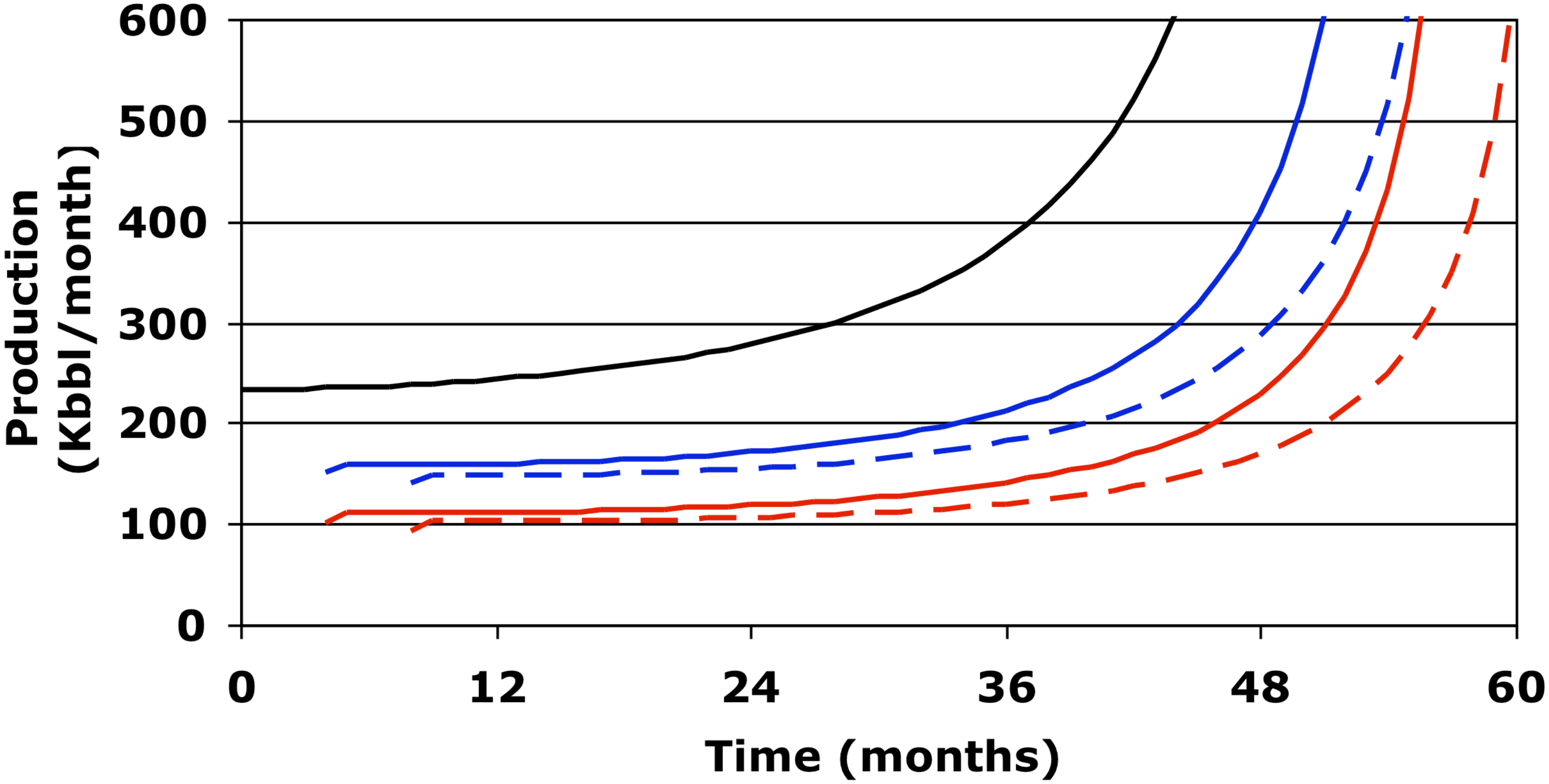
= sum over times t
( forecast cash-flow$_t$
* risk-adjusted discount factor $_t$ )

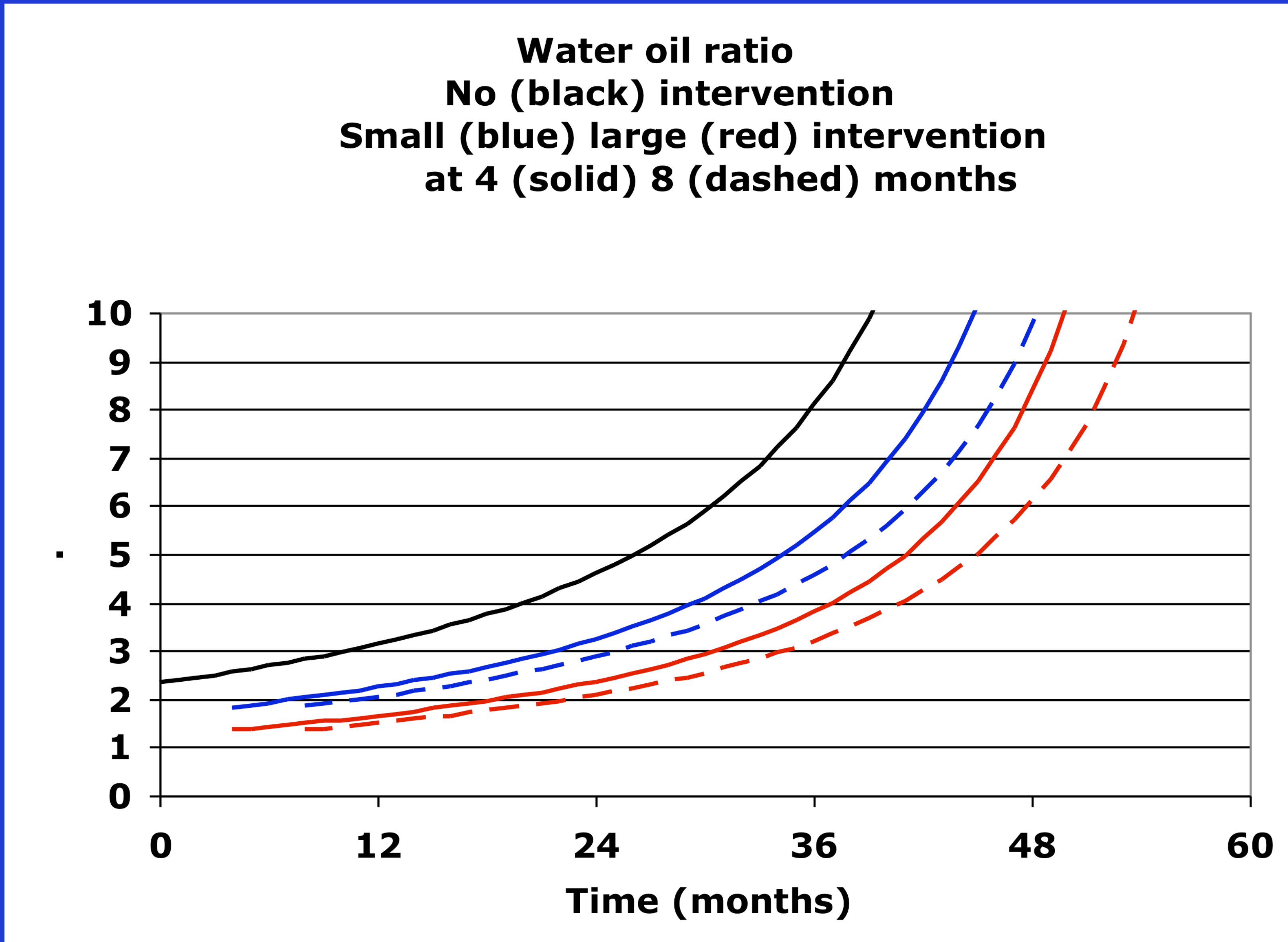
= sum over times t
(( production $_t$ * forecast oil price$_t$ - cost $_t$ )
* corporate risk discount factor $_t$
* time discount factor $_t$)

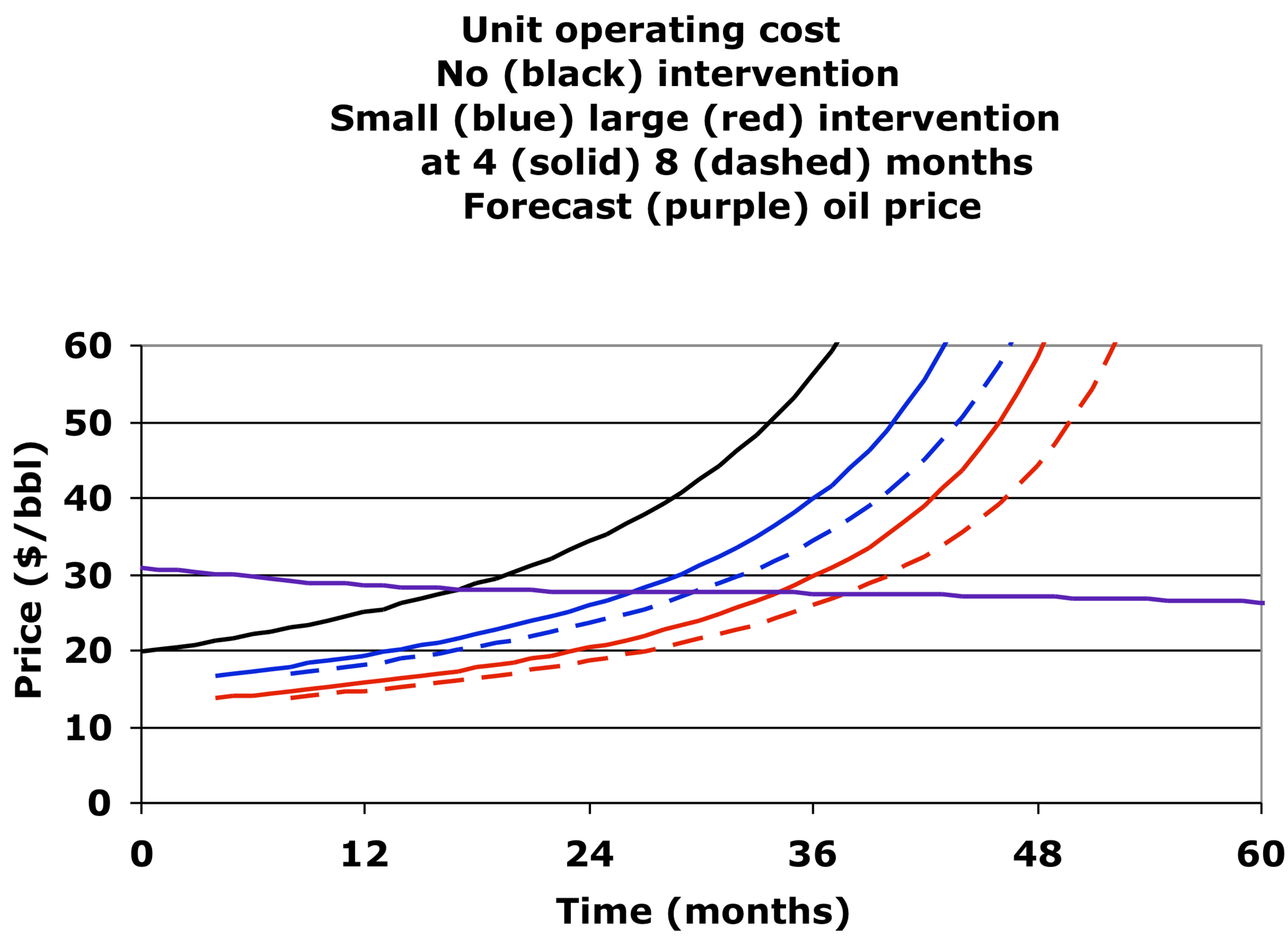

Oil price forecast (20.06.2003)
50
45
40
35
30
25
20
15
10
5
0
Price ($/bbl)
0
12
24
36
48
60
Term (months)


Oil production
No (black) intervention
Small (blue) large (red) intervention
at 4 (solid) 8 (dashed) months
Production
(Kbbl/month)
100
80
60
40
20
0
0
12
24
36
48
60
Time (months)

# Water production
## No (black) intervention
## Small (blue) large (red) intervention
## at 4 (solid) 8 (dashed) months




Water oil ratio
No (black) intervention
Small (blue) large (red) intervention
at 4 (solid) 8 (dashed) months
10
9
8
7
6
5
4
3
2
1
0
0
12
24
36
48
60
Time (months)

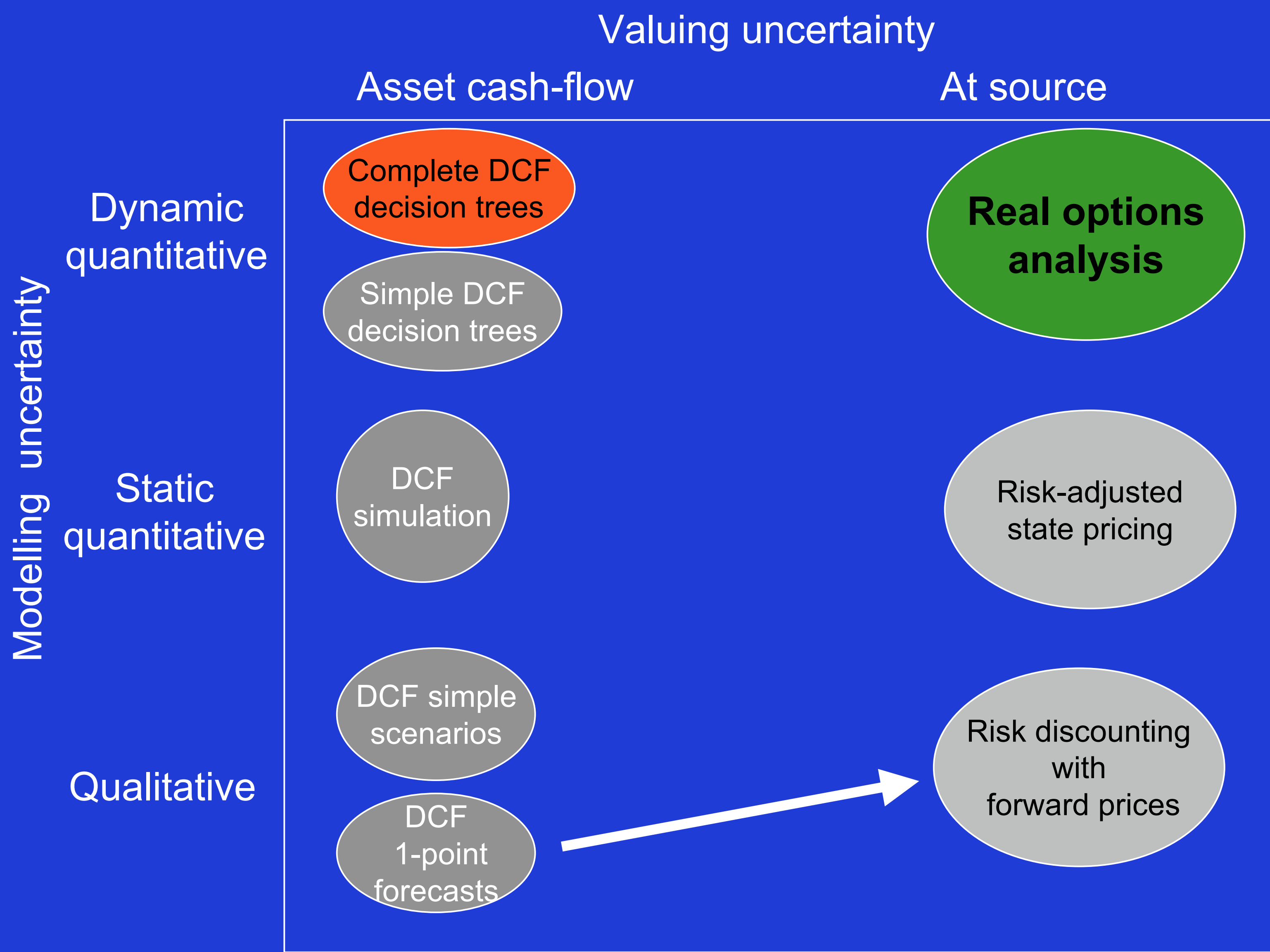

Unit operating cost
No (black) intervention
Small (blue) large (red) intervention
at 4 (solid) 8 (dashed) months
Forecast (purple) oil price
Price ($/bbl)
60
50
40
30
20
10
0
0
12
24
36
48
60
Time (months)

# DCF results (10% per year)

| # | Economic limit (Months) | Value ($M) |
|---|---|---|
| 0 | 18 | 8.1 |
| 1 | 27 | 9.1 |
| 2 | 35 | 10.0 |
| 3 | 30 | 9.9 |
| **4** | **39** | **10.5** |

Economic limit
= optimal pre-specified time for closure

# Shifting to the right



# Mechanics of shift to right

DCF value of the oil field = sum over times t

(( production $_t$ * forecast oil price$_t$ - cost $_t$ )

* corporate risk discount factor $_t$

* time discount factor $_t$)

Value of the oil field = sum over times t

(( production $_t$ * forecast oil price$_t$

* oil price risk discount factor$_t$ - cost $_t$ )

* time discount factor $_t$)

Note valuation of uncertainty at source in MBV.

# Partitioning cash flow for valuation

Can show, using **Law of One Price (value additivity)**,

value of the oil field

= sum over times t

( production $_t$ * value of claim to oil price$_t$

- cost $_t$ * unit price of a claim to risk-free cash-flow at time t )

↗

time discount factor $_t$

# Separating effects of risk and time

Can show, using **Law of One Price (forward pricing)**

value of claim to oil $\text{price}_t$
= forward oil $\text{price}_t$
* unit price of risk-free cash-flow at time t

↗

time discount factor $_t$

By trading uncertainty for certainty, the forward price is the oil price discounted for risk

# Separating effects of risk and time

Value of the oil field = sum over times t

( $production_t$ * oil forward $price_t$ * time discount $factor_t$

- $cost_t$ * time discount $factor_t$)

= sum over time t

(( $production_t$ * oil forward $price_t$ - $cost_t$ )

* time discount $factor_t$)

= sum over times t

(( $production_t$ * forecast oil $price_t$

* oil price risk discount $factor_t$ - $cost_t$ )

* time discount $factor_t$)

# Oil price uncertainty

Oil price forecasts follow a probabilistic process:

- 1-factor — One bit of information in each period
- geometric — Change in forecast proportional to forecast
- diffusion — Also proportional to
  a normally distributed variable
  with variance proportional
  to the period of time over short periods

Short-term forecast uncertainty:
40% in annual terms (2% daily)

Dependence of forecast uncertainty on term:
Exponential decay with 12 month half-life

# Oil price risk discounting
# Time discounting

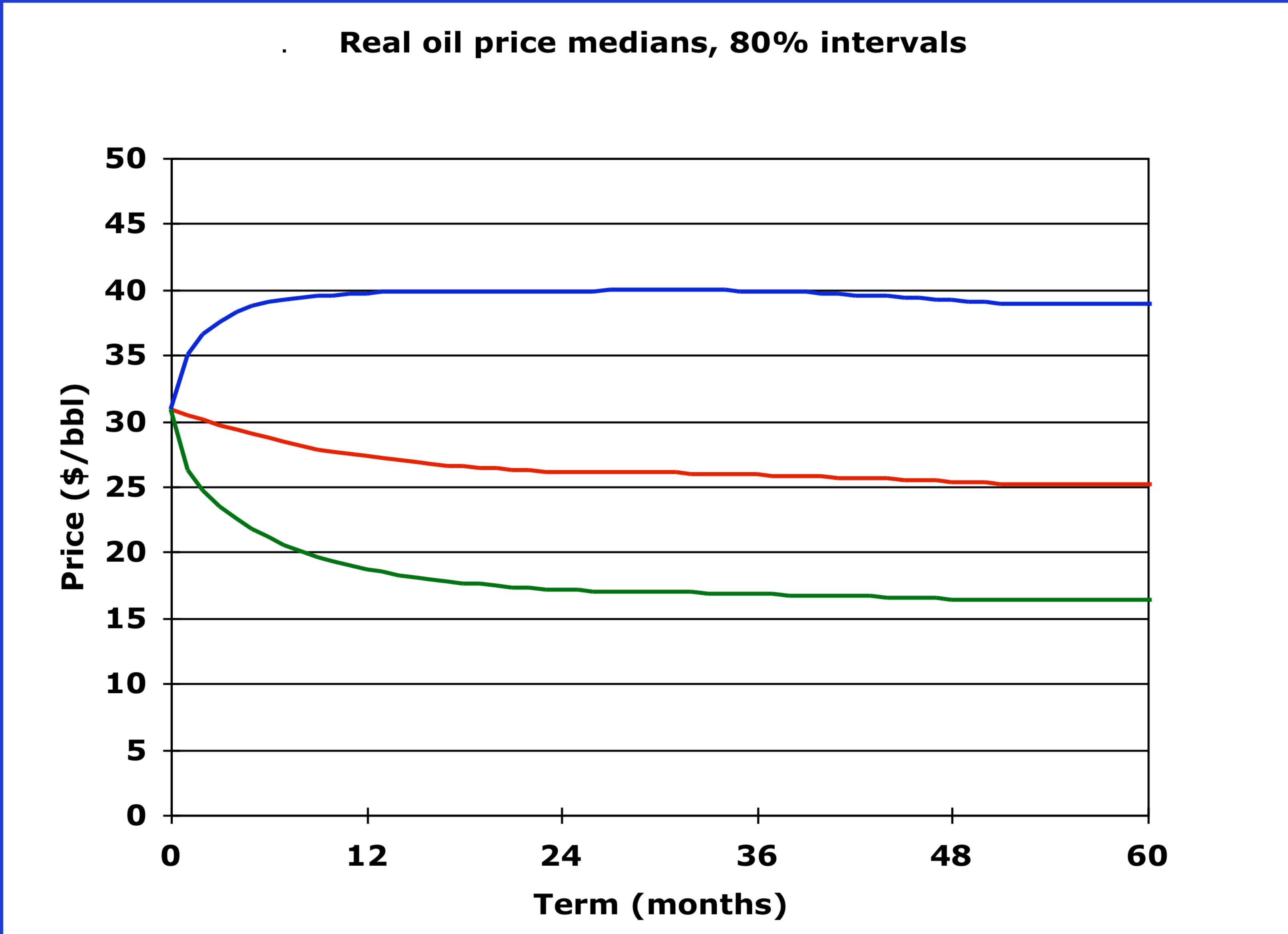
Oil price risk discounting:

4% per year for each 10%

in annual oil price forecast uncertainty

3% per year real risk-free rate

2.5% per year inflation


Real oil price medians, 80% intervals
50
45
40
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30
25
20
15
10
5
0
Price ($/bbl)
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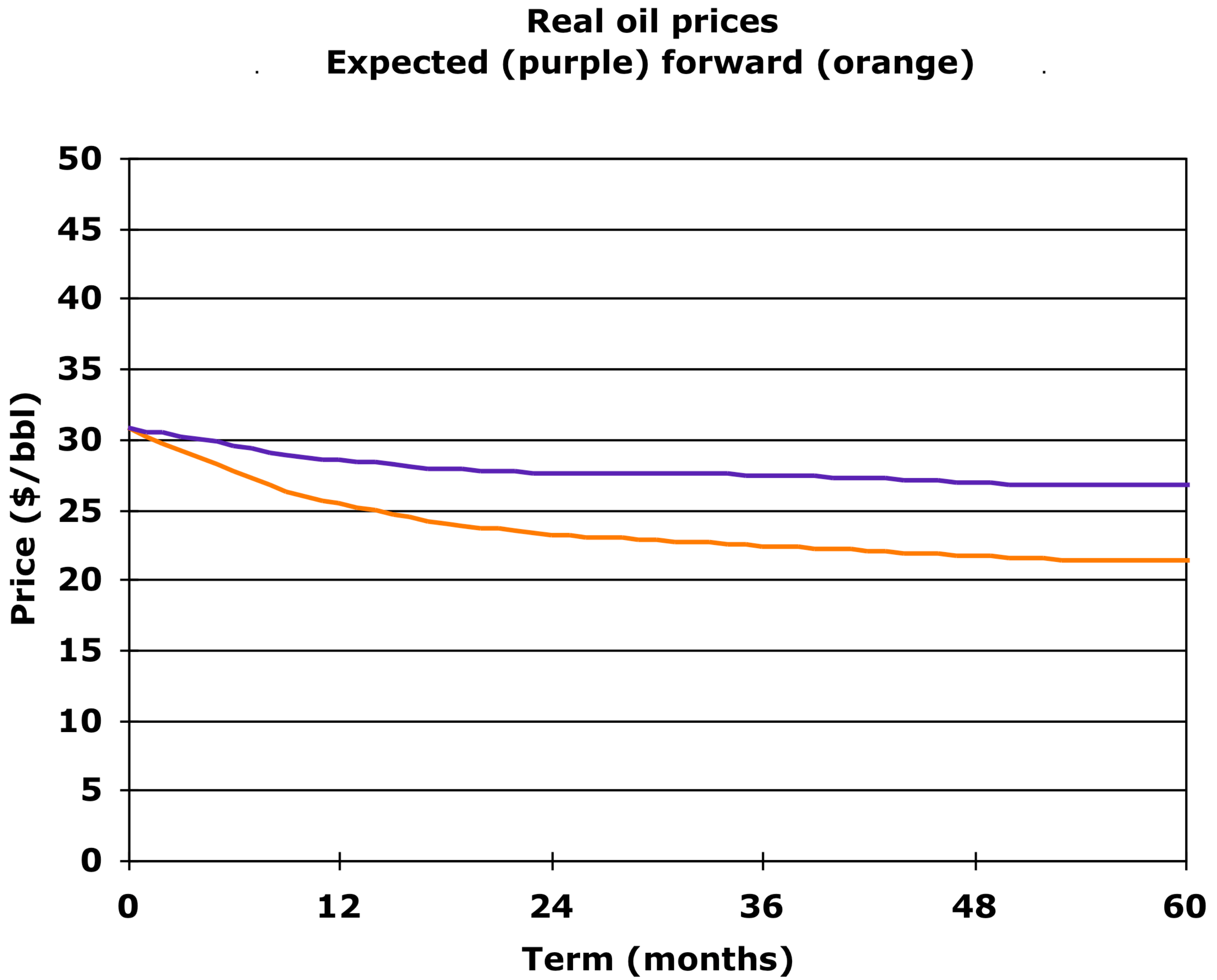
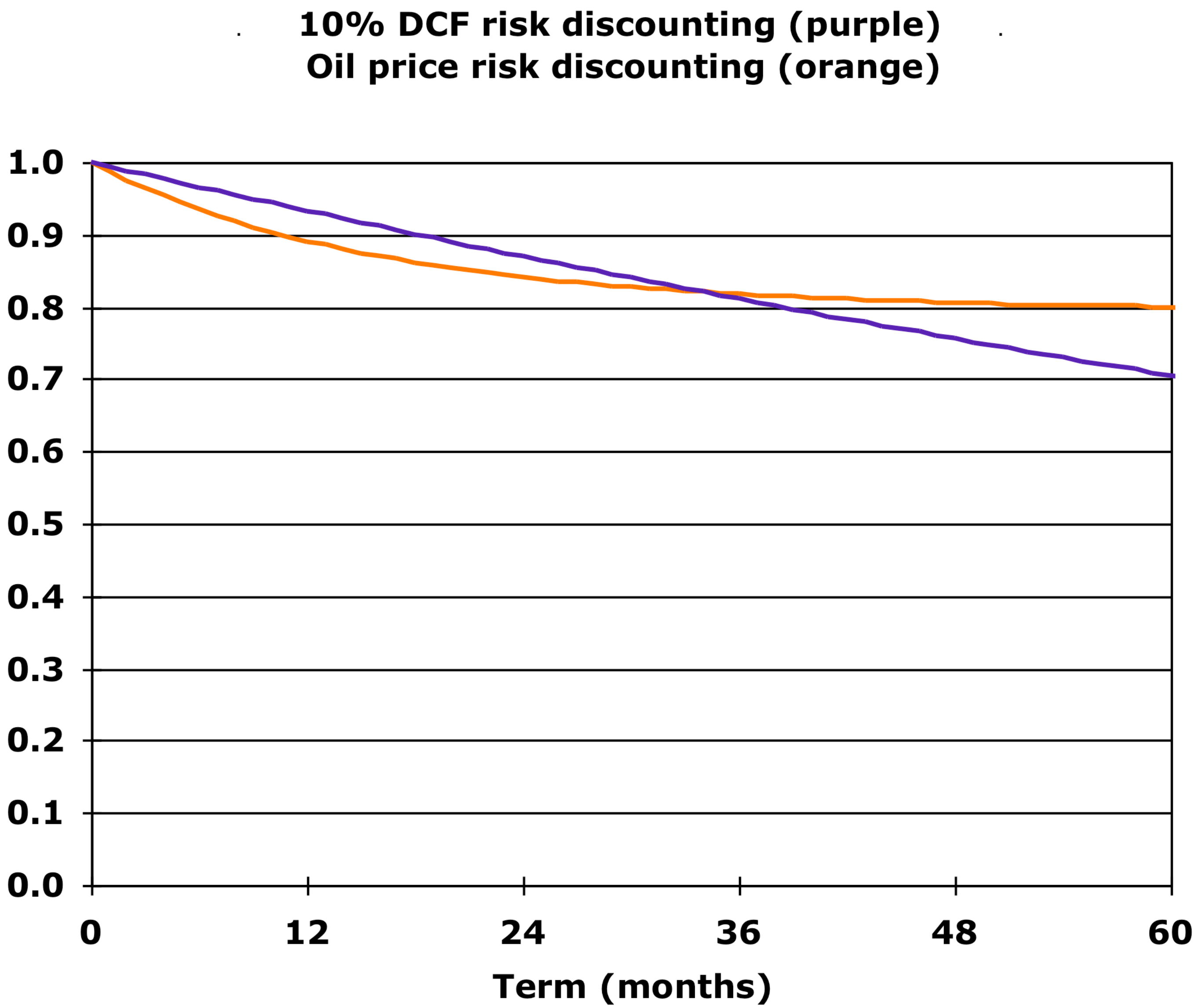
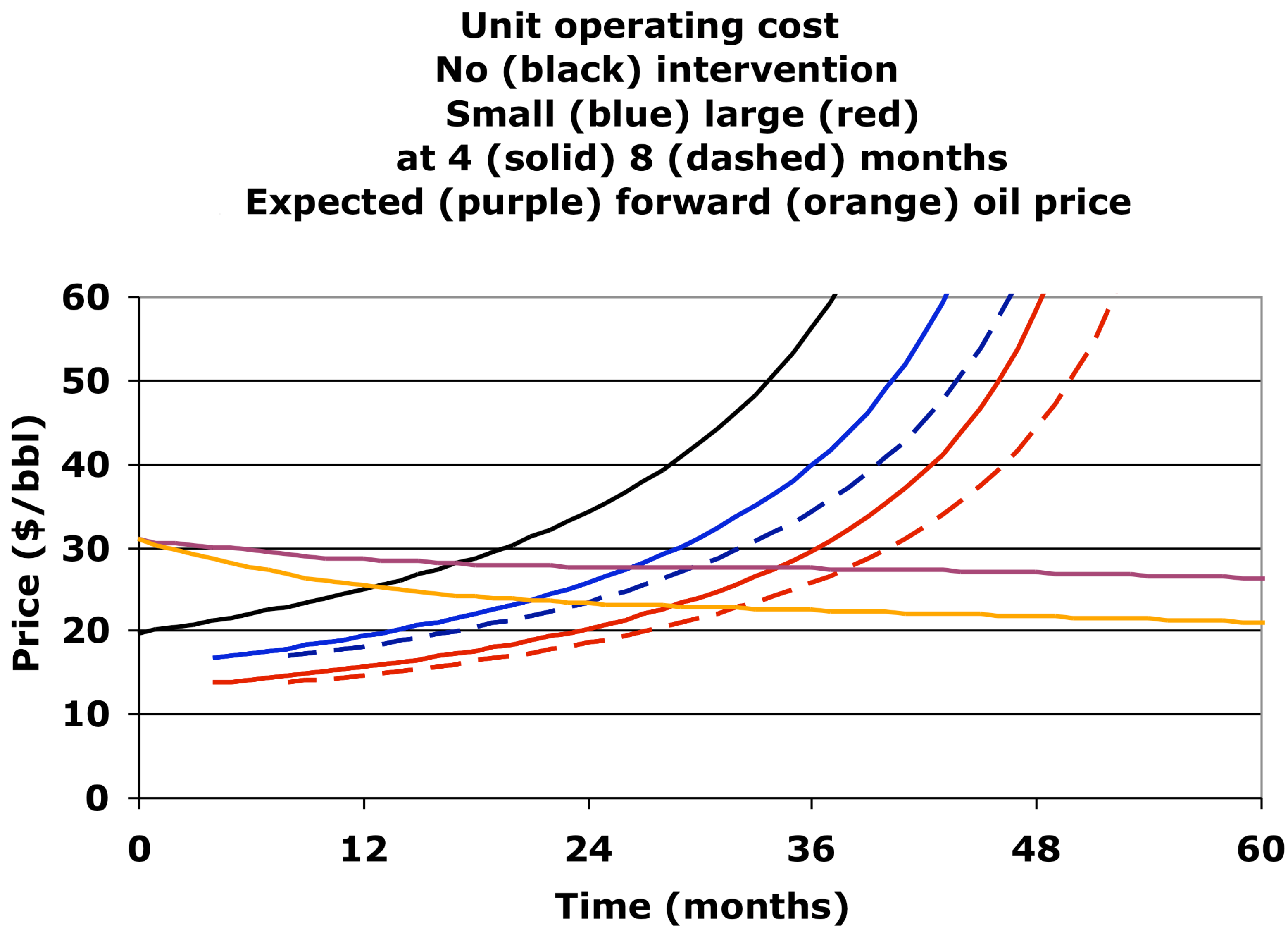
12
24
36
48
60
Term (months)


Real oil prices
Expected (purple) forward (orange)
Price ($/bbl)
50
45
40
35
30
25
20
15
10
5
0
0
12
24
36
48
60
Term (months)


10% DCF risk discounting (purple)
Oil price risk discounting (orange)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
12
24
36
48
60
Term (months)



Unit operating cost
No (black) intervention
Small (blue) large (red)
at 4 (solid) 8 (dashed) months
Expected (purple) forward (orange) oil price
Price ($/bbl)
60
50
40
30
20
10
0
0
12
24
36
48
60
Time (months)

# No intervention analysis (DCF closure choice: 18 months)

| | DCF Value ($M) | MBV Value ($M) | MBV Rate (% per year) |
|---|---|---|---|
| Net | 8.1 | 5.2 | 170 |
| Pretax | 12.1 | 7.7 | 170 |
| Rev | 61.8 | 59.9 | 15 |
| Cost | 49.7 | 52.2 | 3 |
| Tax | 4.0 | 2.5 | 170 |

# DCF and MBV results

| | DCF | | MBV | | | MBV w DCF ec lim | |
|---|---|---|---|---|---|---|---|
| # | Ec lim (Mo) | Value ($M) | Ec lim (Mo) | Value ($M) | Rate (%/yr) | Value ($M) | Rate (%/yr) |
| **0** | 18 | 8.1 | **13** | **5.8** | **107** | 5.2 | 170 |
| 1 | 27 | 9.1 | 21 | 5.3 | 83 | 4.7 | 112 |
| 2 | 35 | 10.0 | 29 | 5.3 | 57 | 4.8 | 69 |
| 3 | 30 | 9.9 | 24 | 5.4 | 112 | 4.8 | 150 |
| **4** | **39** | **10.5** | 33 | 5.1 | 82 | **4.5** | **103** |

**Using DCF** suggested policy **destroys 22%** of value

# DCF and MBV results:
# The source of the difference

DCF: Intervene big and late

MBV: The benefit of intervention not the worth the cost

DCF at 10% overvalues future revenues out to 34 months

DCF at 10% undervalues all future costs
including the cost of intervention
-- more so the later the intervention

DCF at 10% biased toward late, large intervention

# Future flexibility

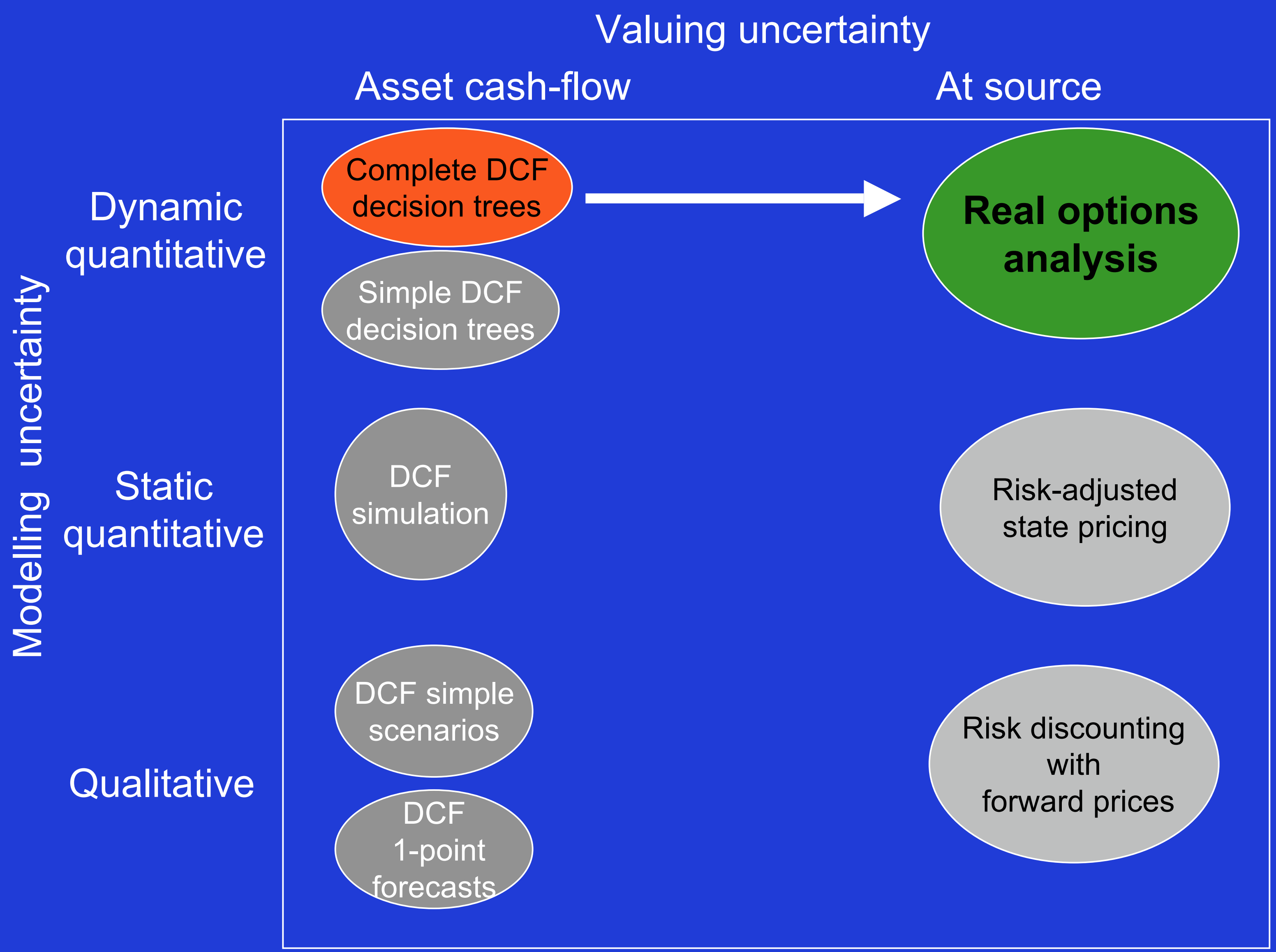
How much value is added if decisions are made,
not unconditionally now,
but conditional on events up to the time
action is taken?

Examine a monthly decision on
whether to abandon or continue production

Next add in various combinations of flexibility in
intervention

Finally examine the effect of uncertainty in production of
oil and/or water as a result of intervention

# Complete decision trees



# Determining a contingent economic limit

Uncertainty in cash-flows due only to oil price uncertainty

Set up a scenario tree for oil prices
based on probabilistic process for oil price forecasts

Can show that, in the given model, at any given time,
the future has the same structure for all states
with the same contemporaneous oil price

Abandonment decision at any time,
if field is still in operation, depends on the price
Low price => abandon
High price => continue

For each time, find the optimal critical price between
the continue and abandon phases

# Using dynamic programming

Start at an horizon far in the future

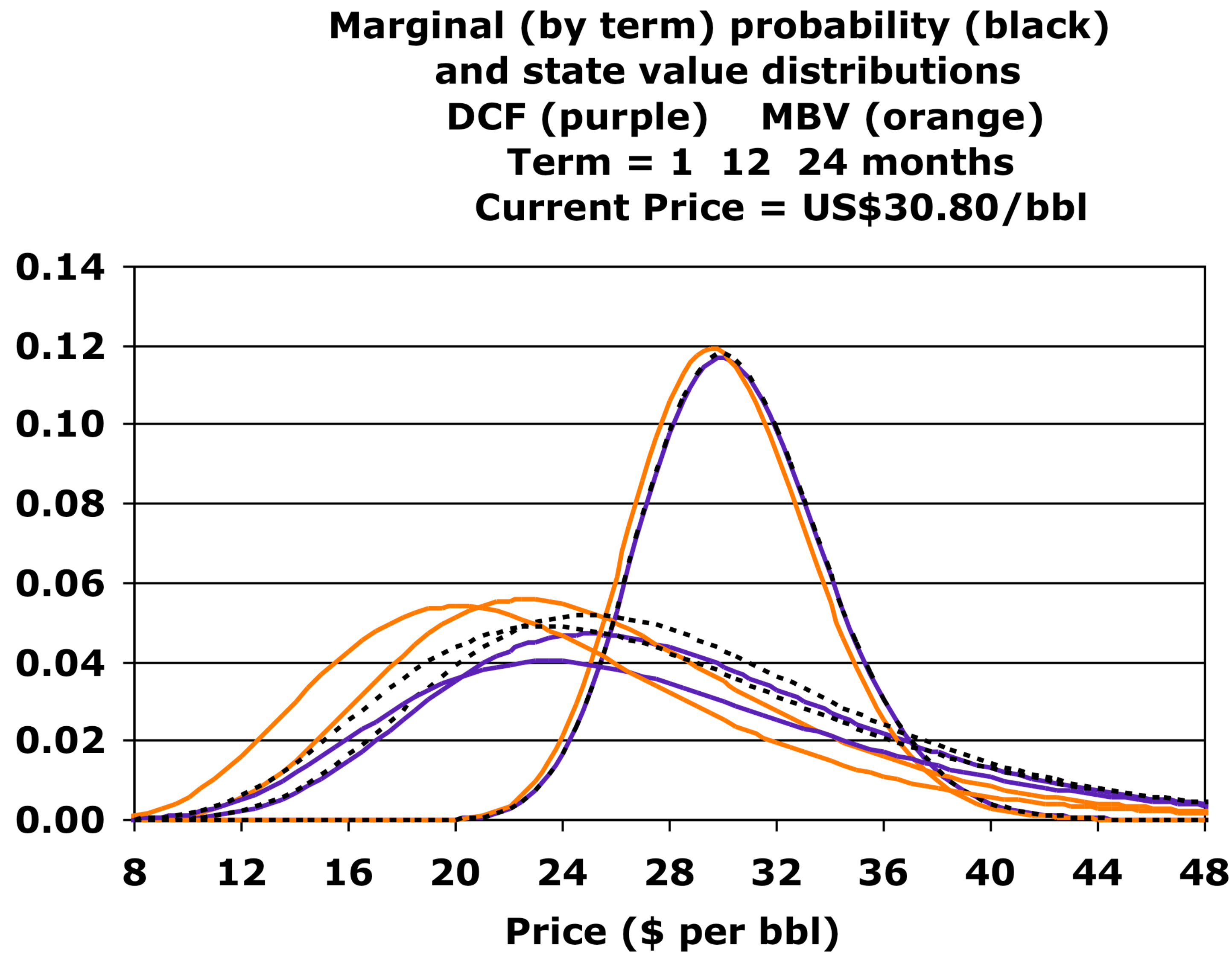
Force abandonment in each state at that time

Work back through time
making monthly decisions optimal in each state

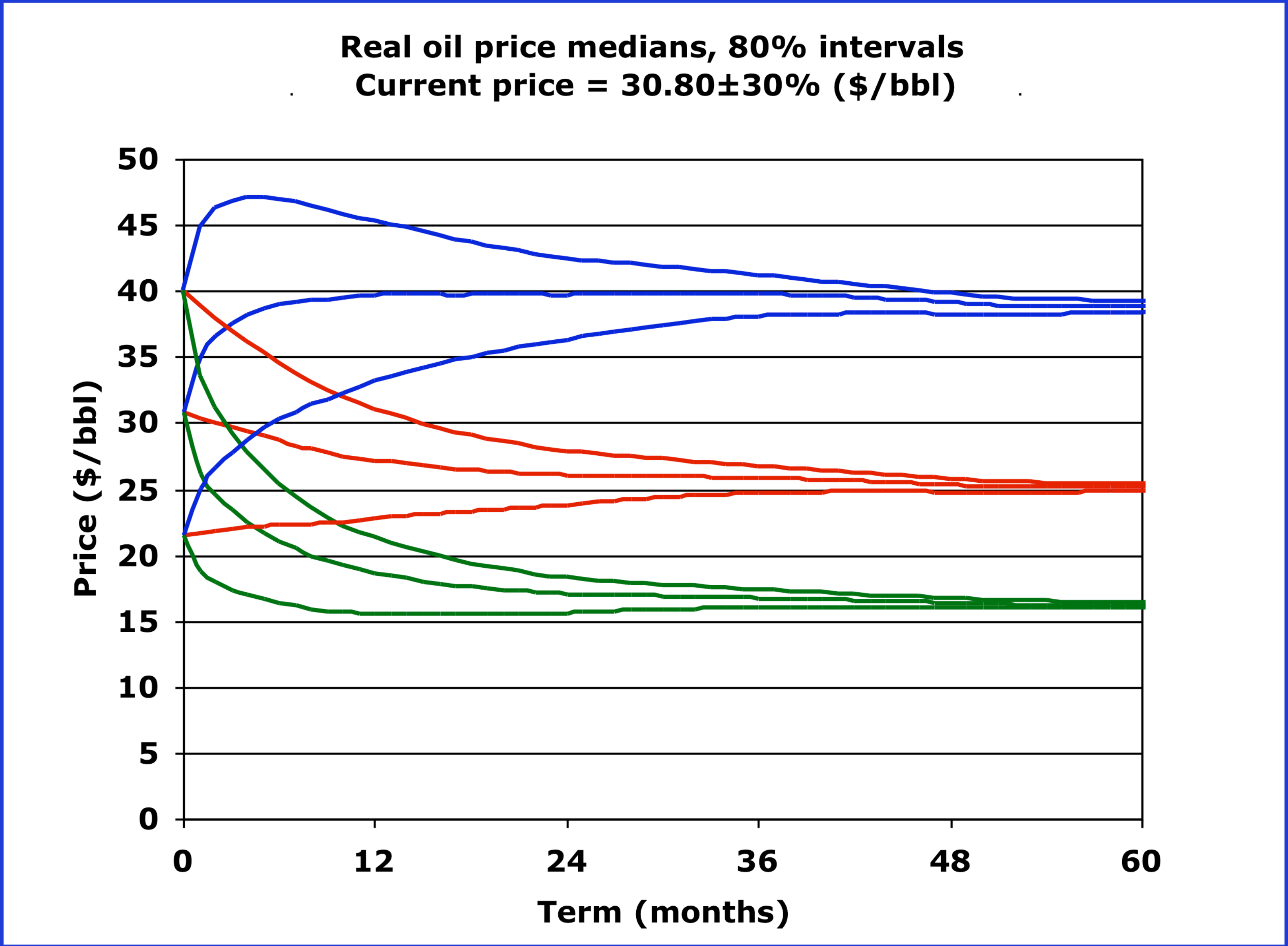
Accrue monthly cash-flows in each state

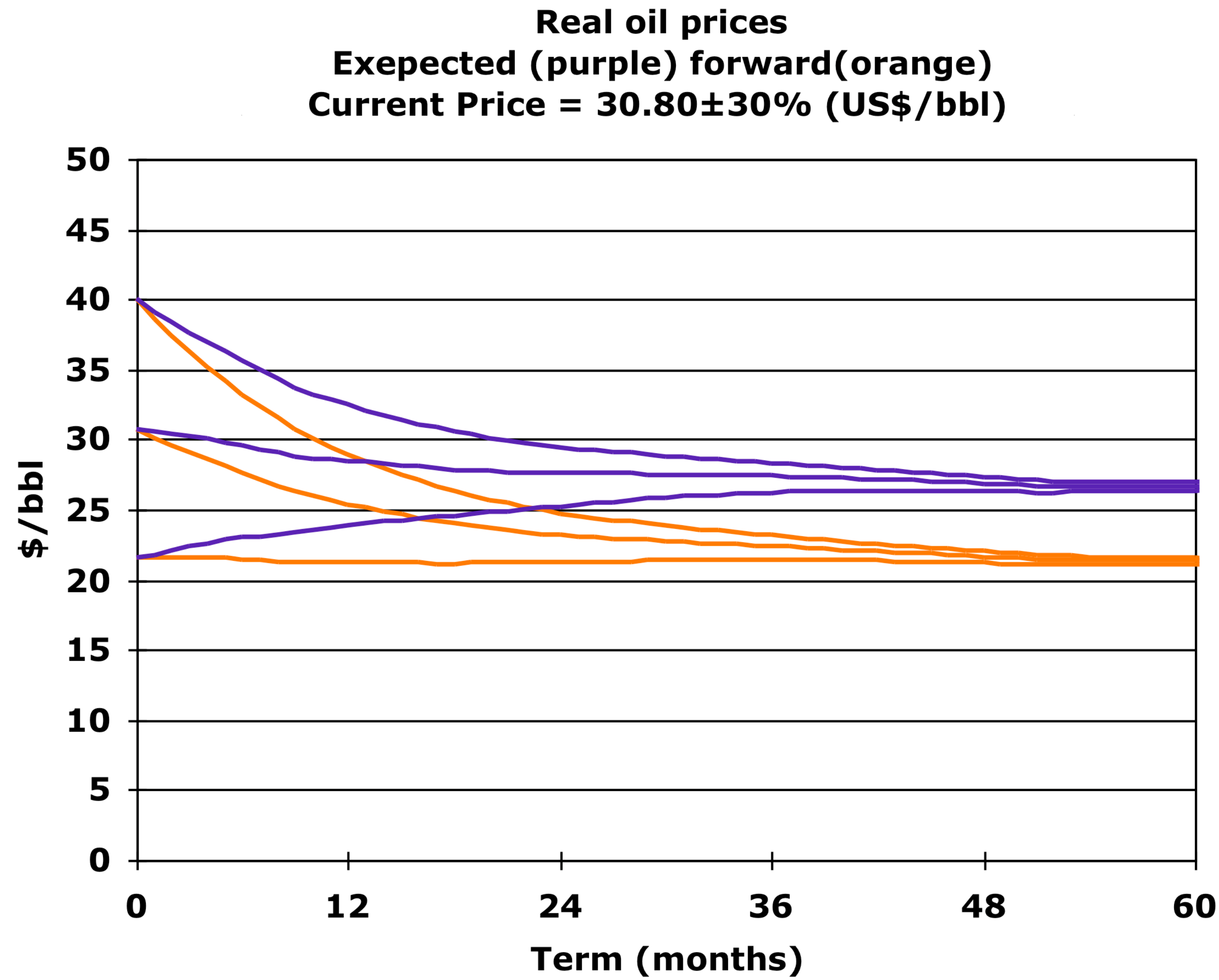
In each state, add value from states one month thence, weighting the value from these future states:

by discounting the conditional (risk-adjusted/true) expectation of that value with the risk-free/risk-adjusted discount rate (MBV/DCF)



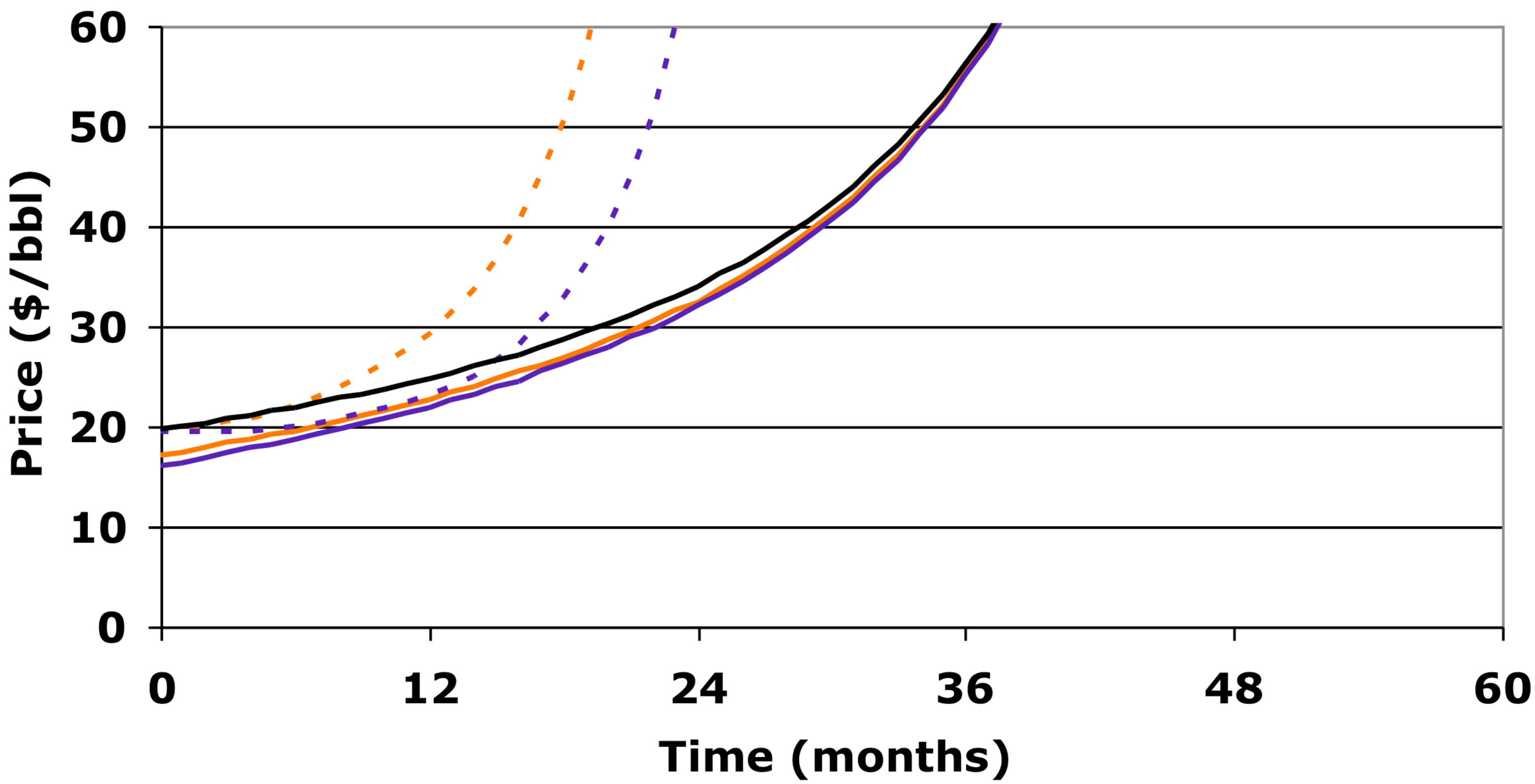
Marginal (by term) probability (black)
and state value distributions
DCF (purple) MBV (orange)
Term = 1 12 24 months
Current Price = US$30.80/bbl
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
8
12
16
20
24
28
32
36
40
44
48
Price ($ per bbl)

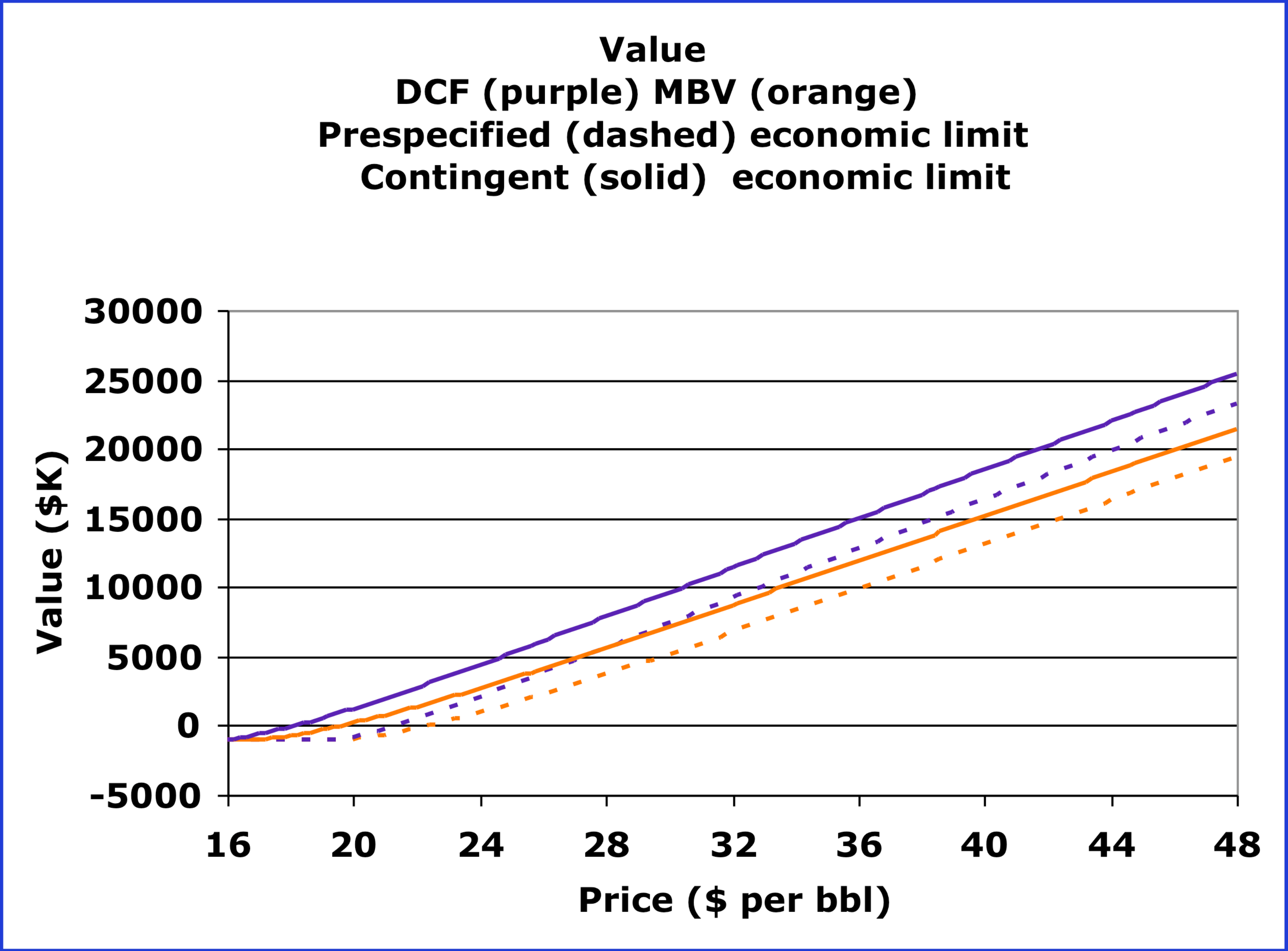

Real oil price medians, 80% intervals
Current price = 30.80±30% ($/bbl)
Price ($/bbl)
50
45
40
35
30
25
20
15
10
5
0
0
12
24
36
48
60
Term (months)



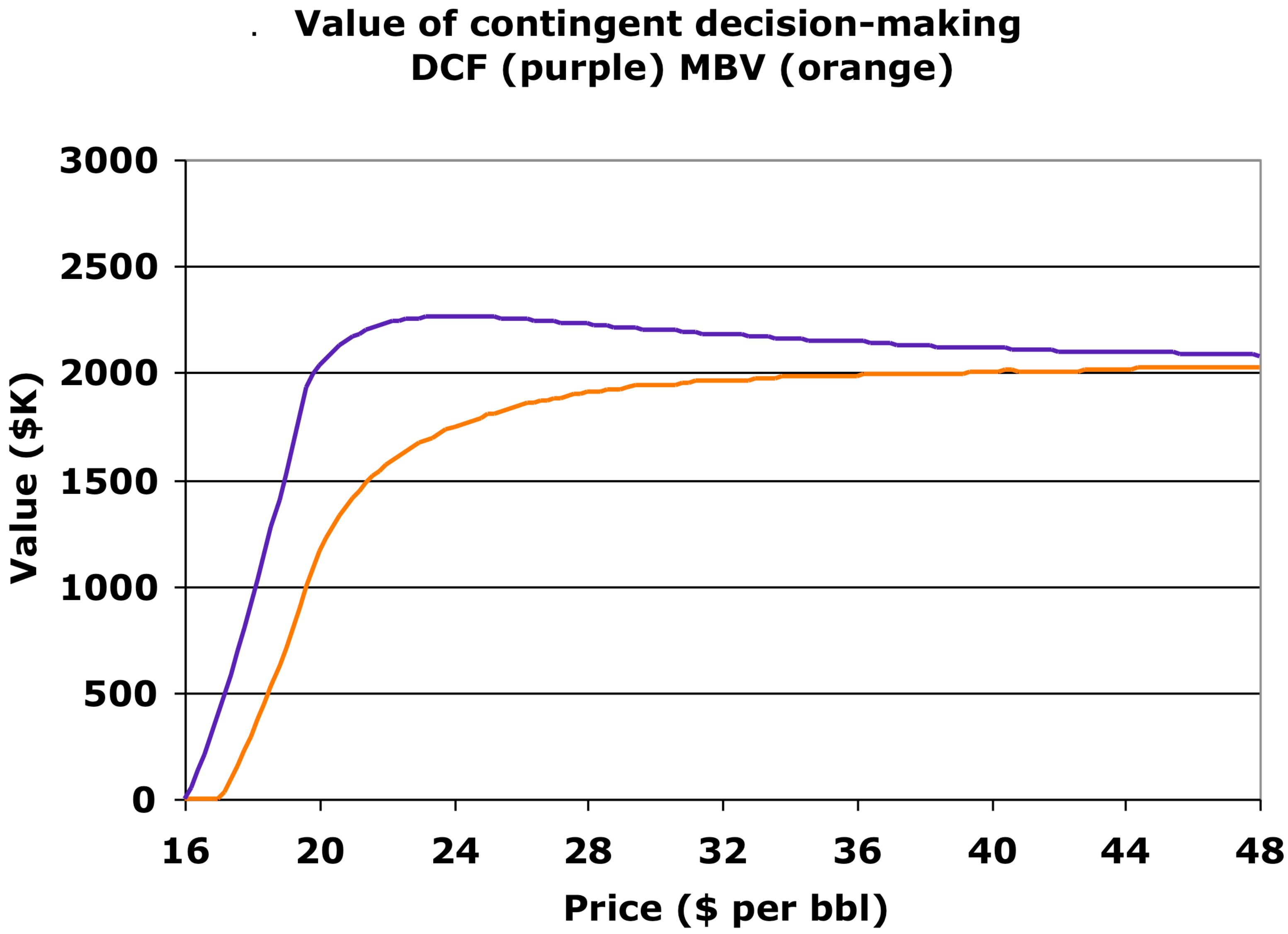
Real oil prices
Exepected (purple) forward(orange)
Current Price = 30.80±30% (US$/bbl)
50
45
40
35
30
25
20
15
10
5
0
$/bbl
0
12
24
36
48
60
Term (months)

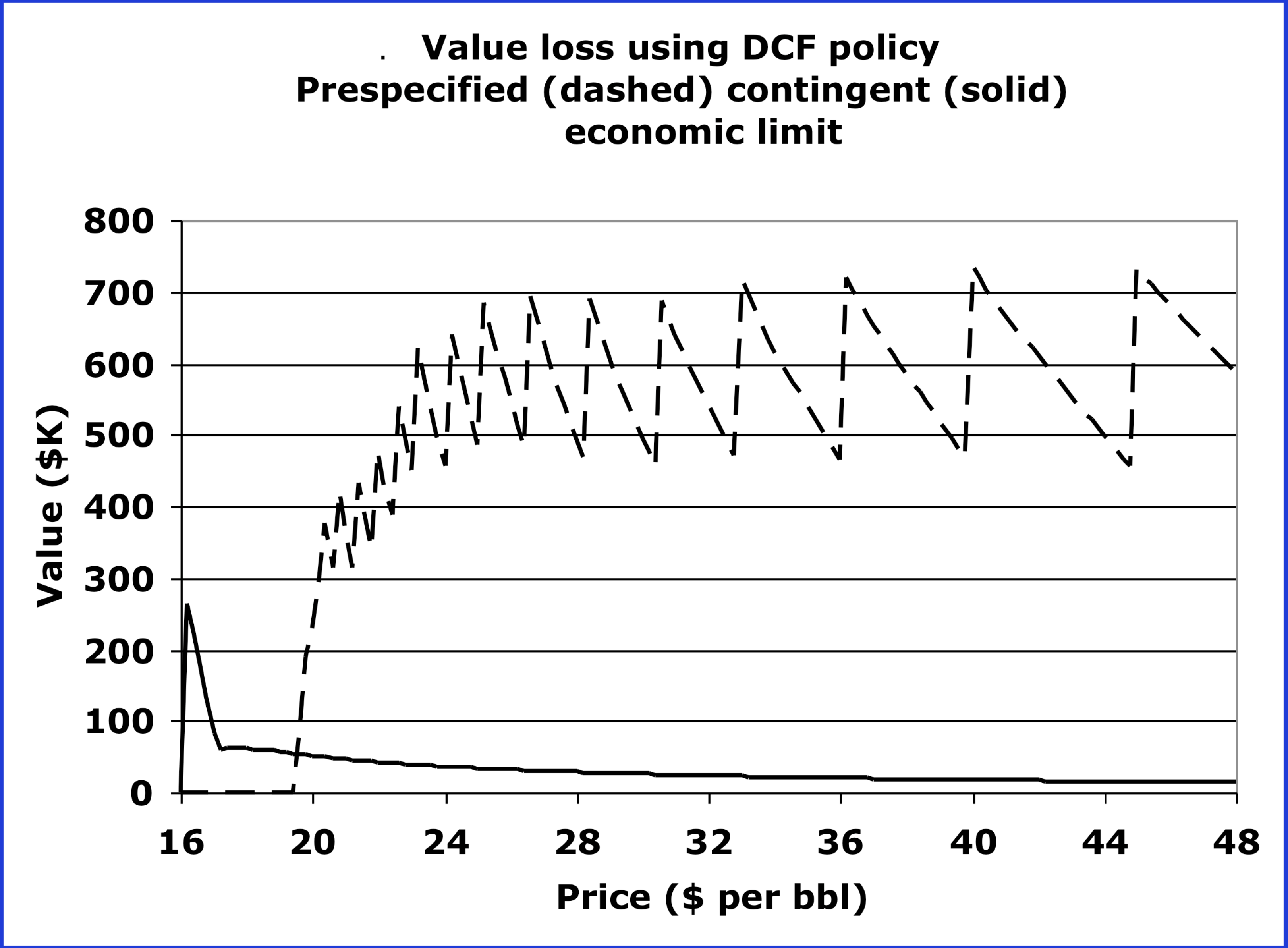
**Economic limit**
**Prespecifed (dotted) vs current price**
**Contingent (solid) vs contemporaneous price**
**DCF (purple) MBV (orange)**
**Unit cost (black)**





Value
DCF (purple) MBV (orange)
Prespecified (dashed) economic limit
Contingent (solid) economic limit
30000
25000
20000
15000
10000
5000
0
-5000
Value ($K)
16
20
24
28
32
36
40
44
48
Price ($ per bbl)


.
Value of contingent decision-making
DCF (purple) MBV (orange)
3000
2500
2000
1500
1000
500
0
Value ($K)
16
20
24
28
32
36
40
44
48
Price ($ per bbl)


.
Value loss using DCF policy
Prespecified (dashed) contingent (solid)
economic limit
800
700
600
500
400
300
200
100
0
Value ($K)
16
20
24
28
32
36
40
44
48
Price ($ per bbl)

# Comments

Contingent economic limit below unit cost

- Future upside potential
- Delay of closure costs

MBV critical price more than DCF critical price

- MBV weights high price states less
  - =>less value from waiting of price to go up
- MBV weights low price states more
  - =>more value loss from losses in low price states

Current price for given prespecified economic limit
higher than contemporaneous price for
the same contingent limit

- Shape determined by declining forecast, reversion, and, for MBV, by risk discounting

## Comments cont'd

10% DCF value higher than MBV
- MBV implicitly discounting more for risk

Abandonment flexibility worth more under DCF
- Overall scale of DCF valuation higher

Abandonment flexibility most valuable at moderate prices
- At low prices, not much value in any asset policy
- At high prices, abandonment less important

More value loss from using DCF
- if economic limit is prespecified

# Future flexibility

How much value is added if decisions are made,
not unconditionally now,
but conditional on events up to the time
action is taken?

Examine a monthly decision on
whether to abandon or continue production

Next add in various combinations of flexibility in
intervention

Finally examine the effect of uncertainty in production of
oil and/or water as a result of intervention

# Intervention options

Determine economic limits for each intervention

Determine optimal policy for contingent decision
to intervene at 8 months (given none at 4 months)
and at 4 months given optimal decision at 8 months

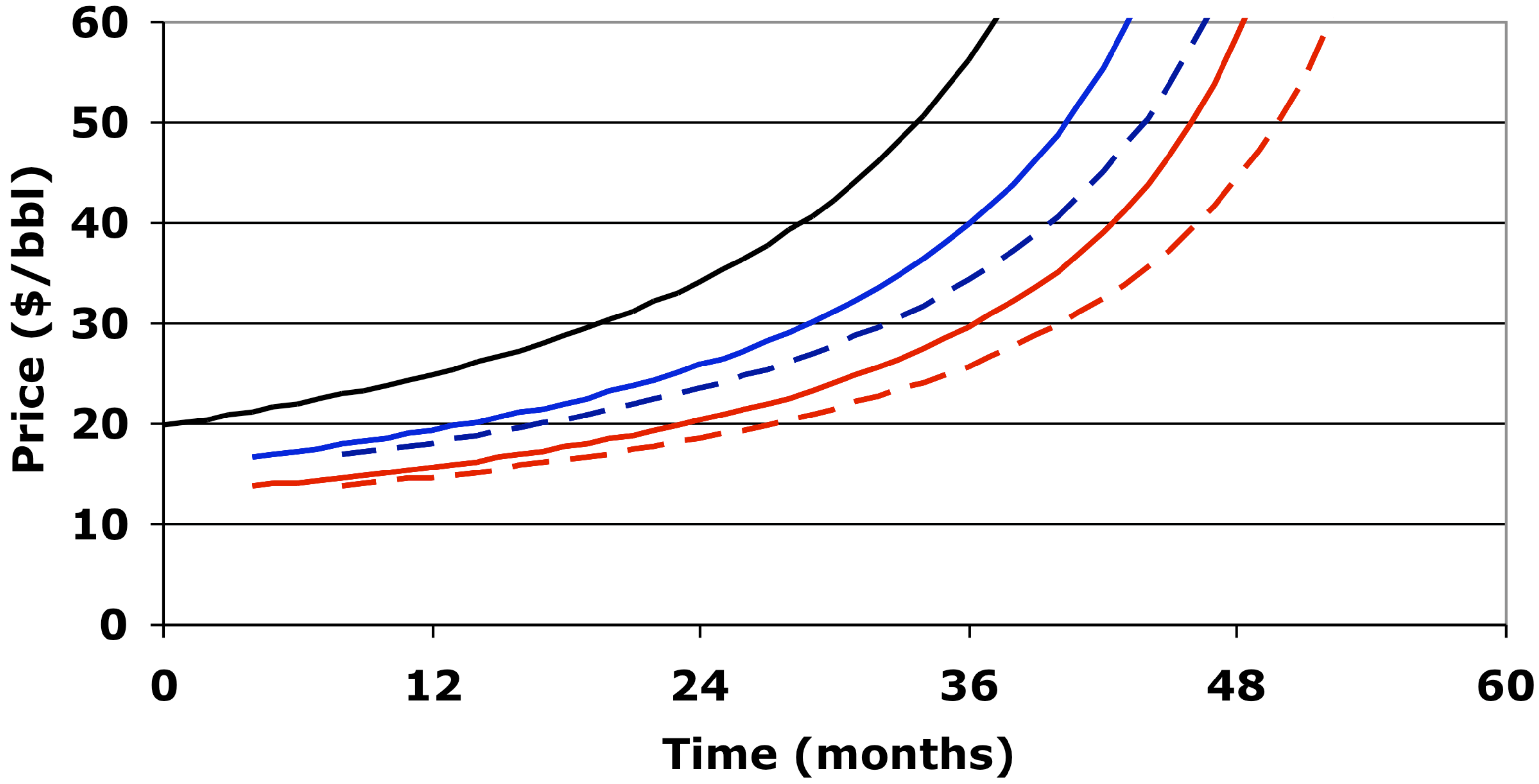
Determine value of contingent intervention options

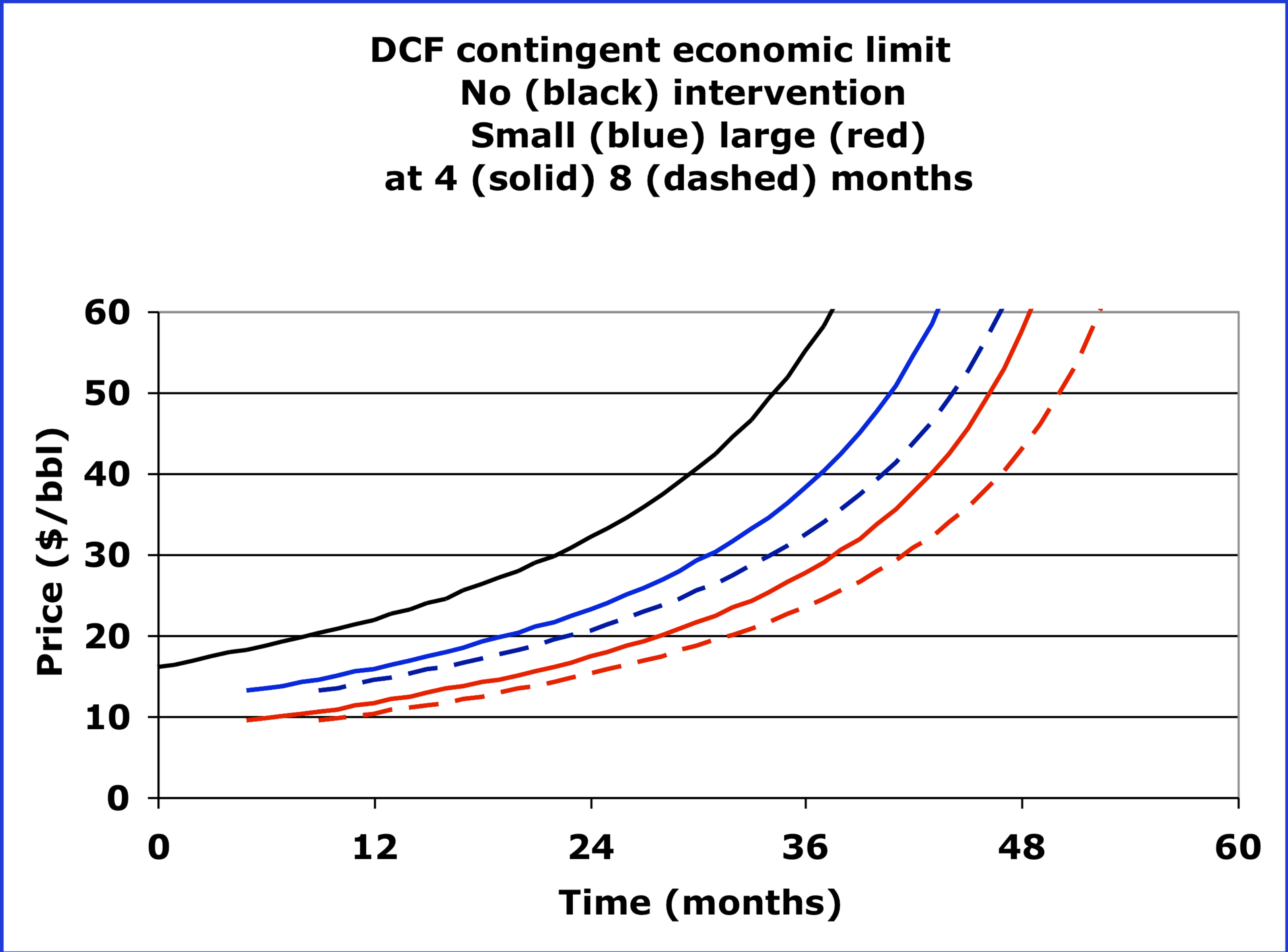
Determine, for each current price, optimal policy for,
and value of, prespecified intervention options

Determine value of contingent decision-making

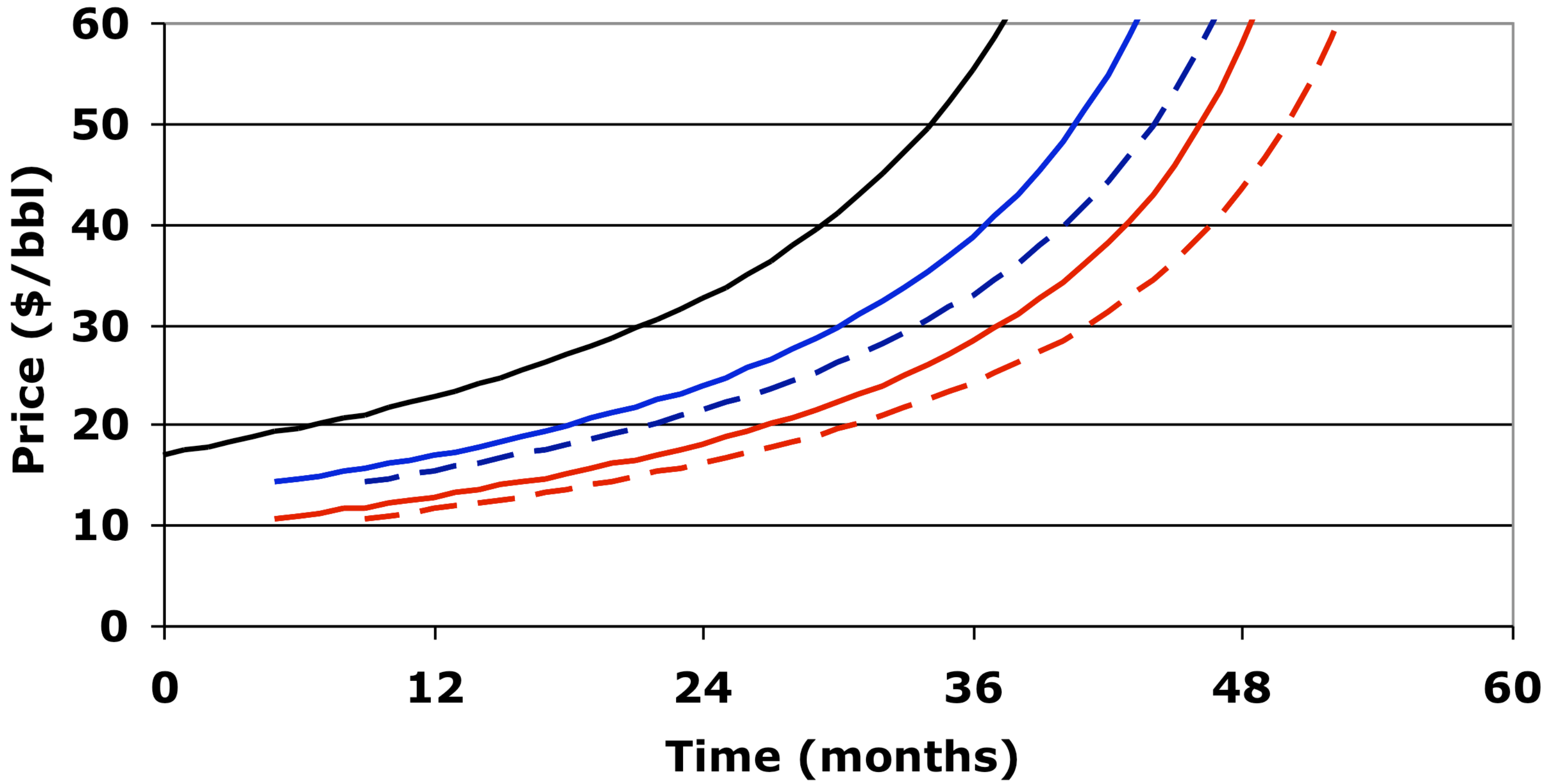
Determine value lost by following DCF policy

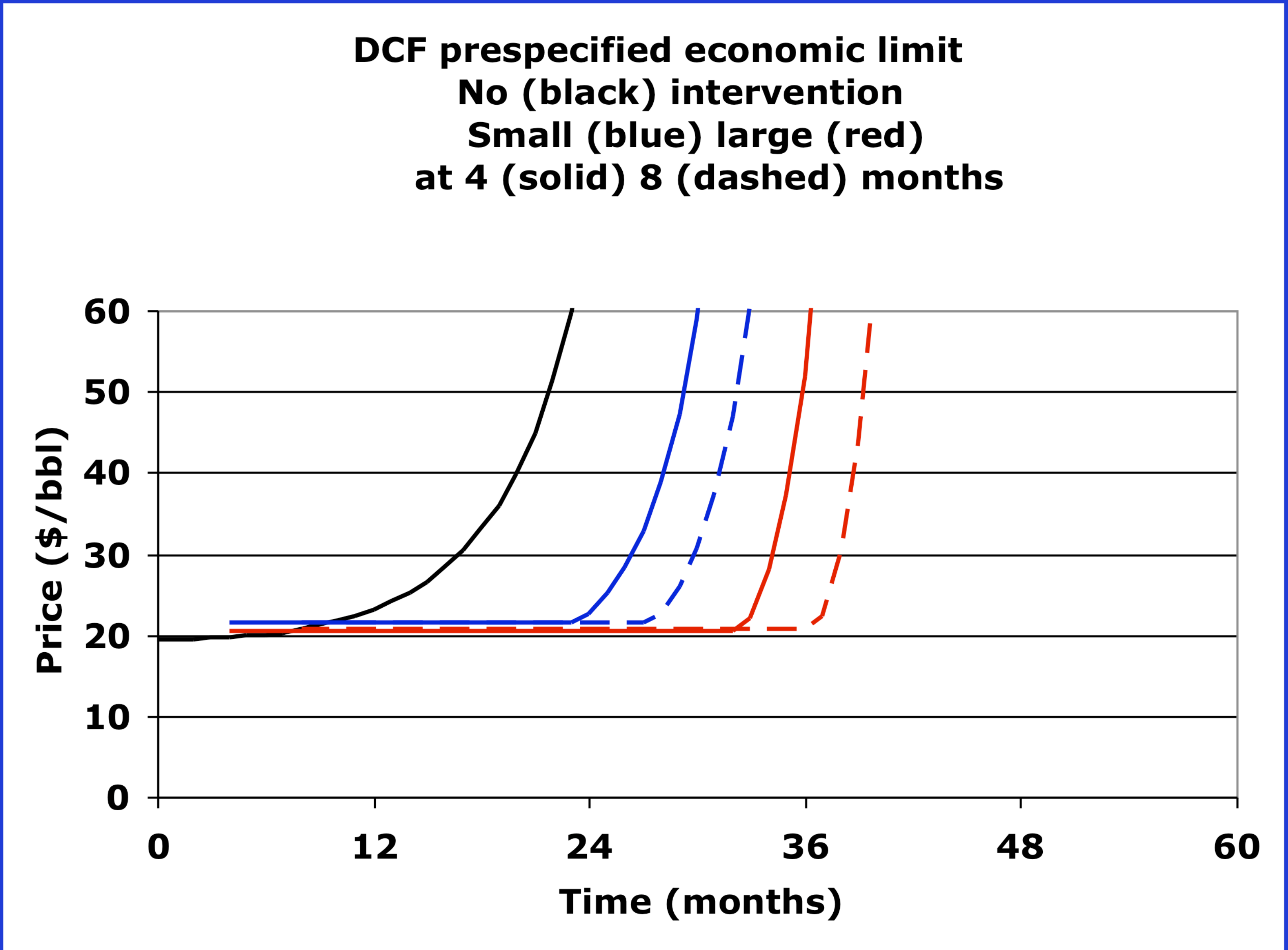
# Unit operating cost
# No (black) intervention
# Small (blue) large (red)
# at 4 (solid) 8 (dashed) months



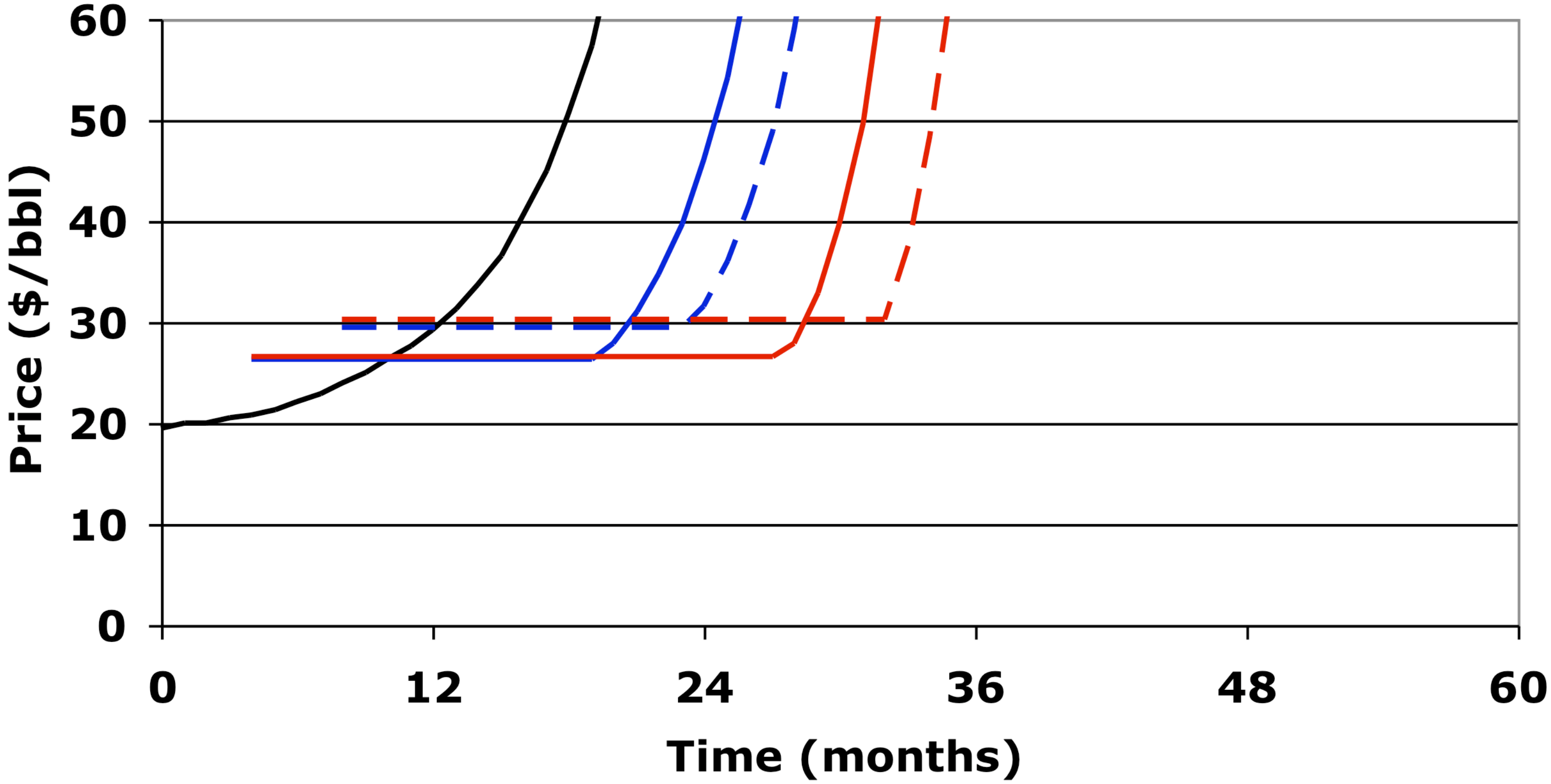

DCF contingent economic limit
No (black) intervention
Small (blue) large (red)
at 4 (solid) 8 (dashed) months
Price ($/bbl)
0
10
20
30
40
50
60
0
12
24
36
48
60
Time (months)

## MBV contingent economic limit
## No (black) intervention
## Small (blue) large (red)
## at 4 (solid) 8 (dashed) months




DCF prespecified economic limit
No (black) intervention
Small (blue) large (red)
at 4 (solid) 8 (dashed) months
Price ($/bbl)
0
10
20
30
40
50
60
0
12
24
36
48
60
Time (months)

## MBV prespecified economic limit
## No (black) intervention
## Small (blue) large (red)
## at 4 (solid) 8 (dashed) months



# Comments

Lower unit cost => longer economic limit

Larger and later interventions reduce unit costs more

DCF vs MBV valuation and
prespecified vs contingent decisions
show same qualitative pattern
with or without an intervention

# Intervention options

Determine economic limits for each intervention

Determine optimal policy for contingent decision
to intervene at 8 months (given none at 4 months)
and at 4 months given optimal decision at 8 months

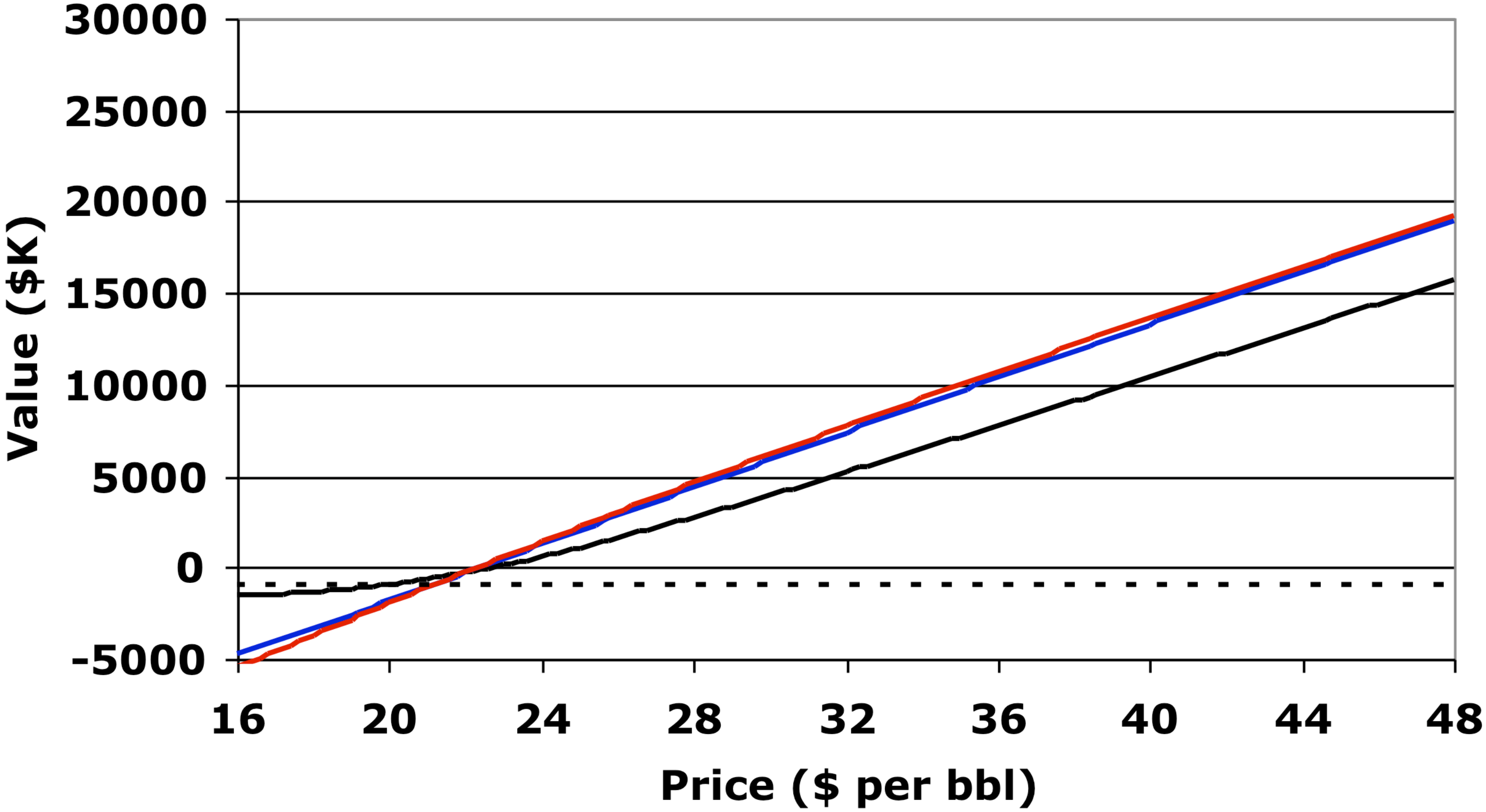
Determine value of contingent intervention options

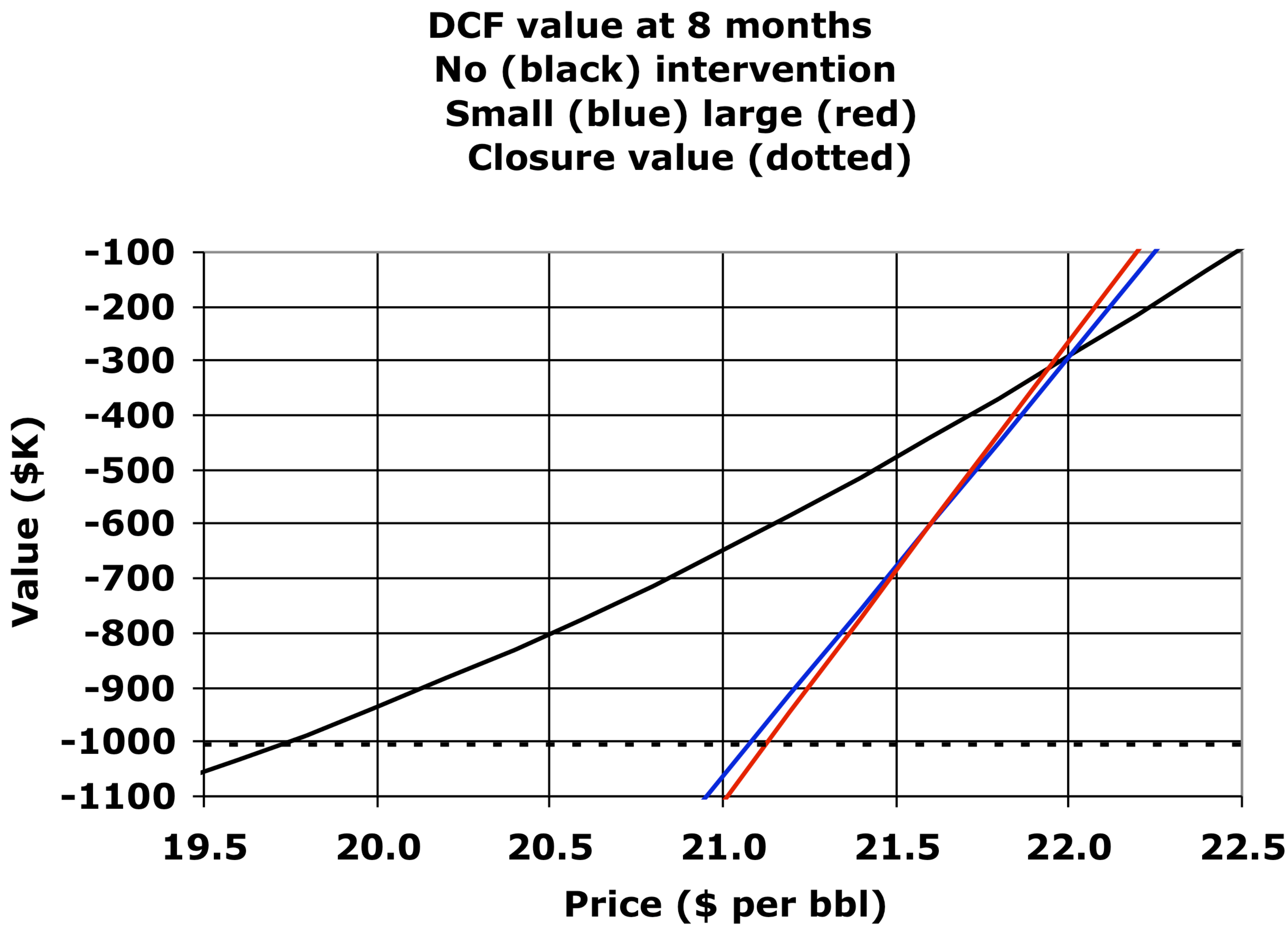
Determine, for each current price, optimal policy for,
and value of, prespecified intervention options

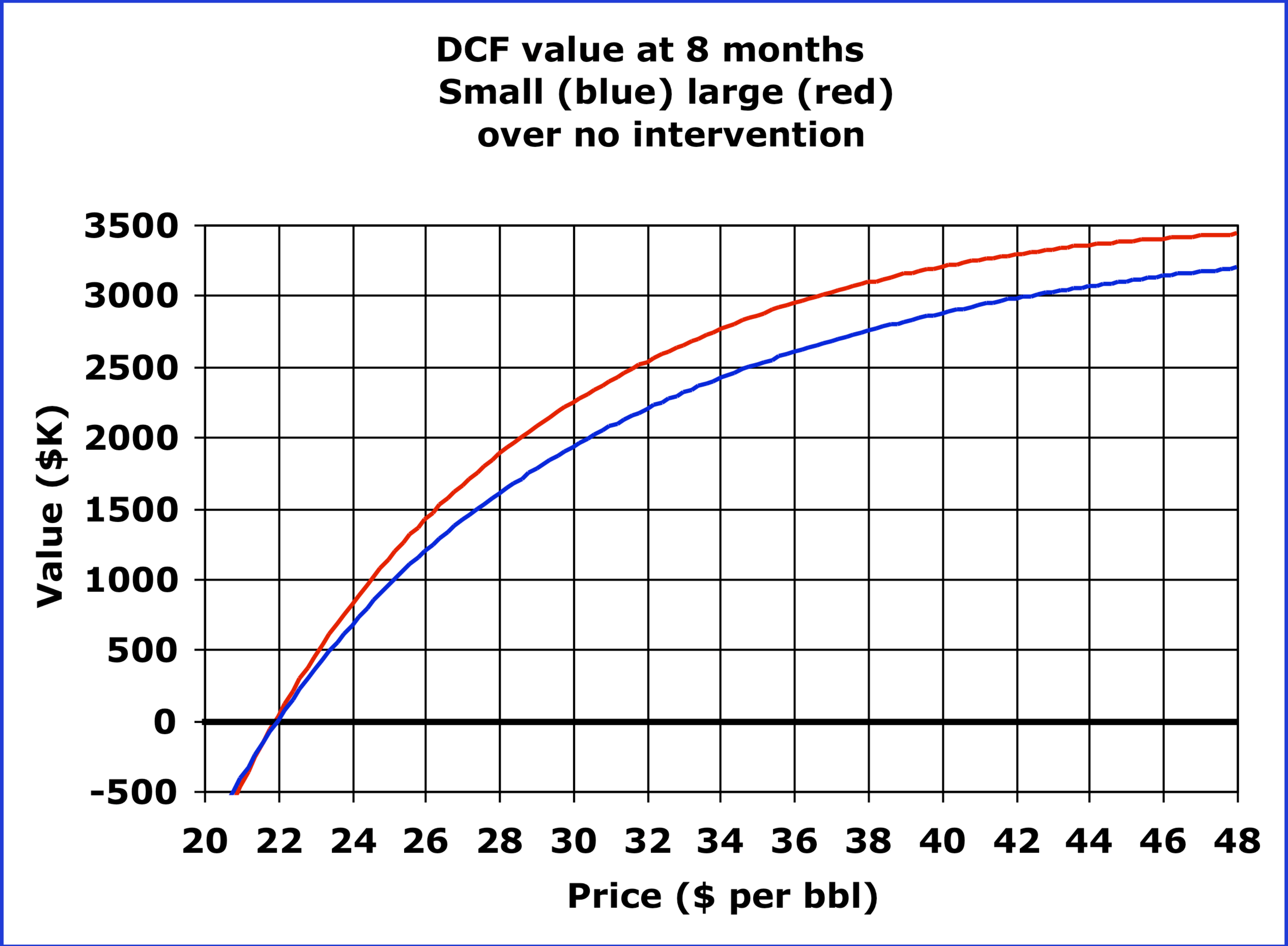
Determine value of contingent decision-making

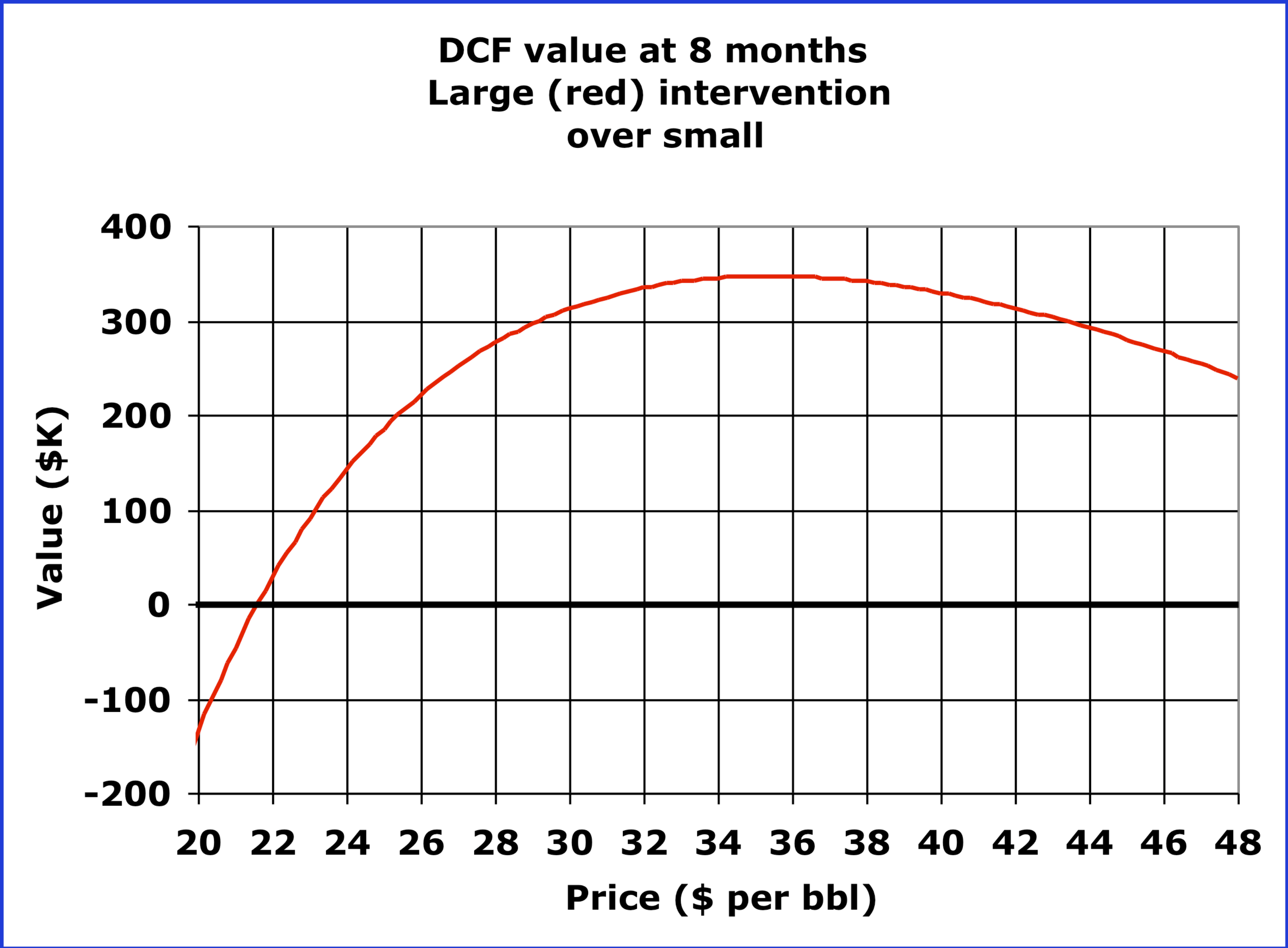
Determine value lost by following DCF policy

# DCF value at 8 months
# No (black) intervention
# Small (blue) large (red)
# Closure value (dotted)

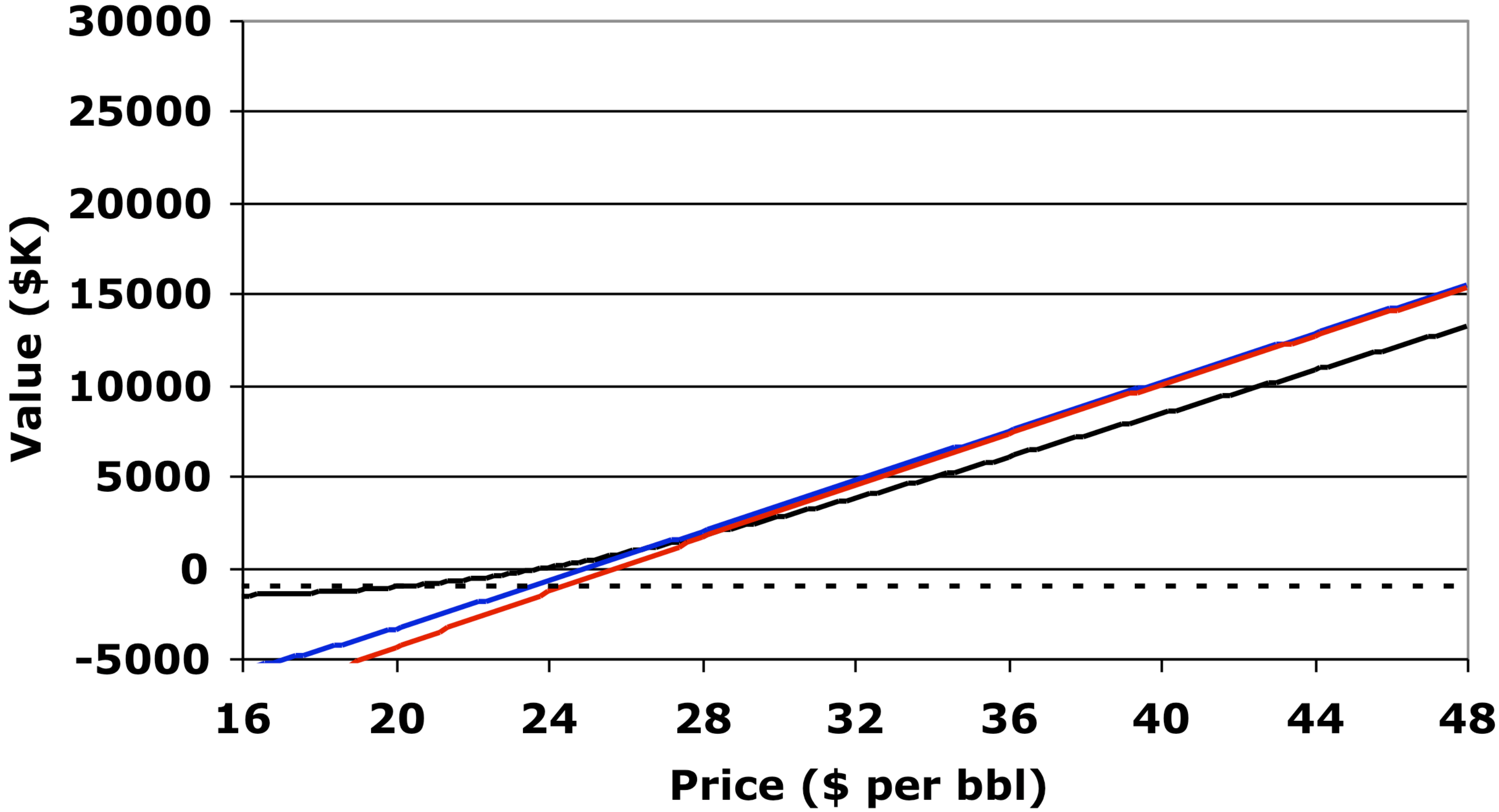


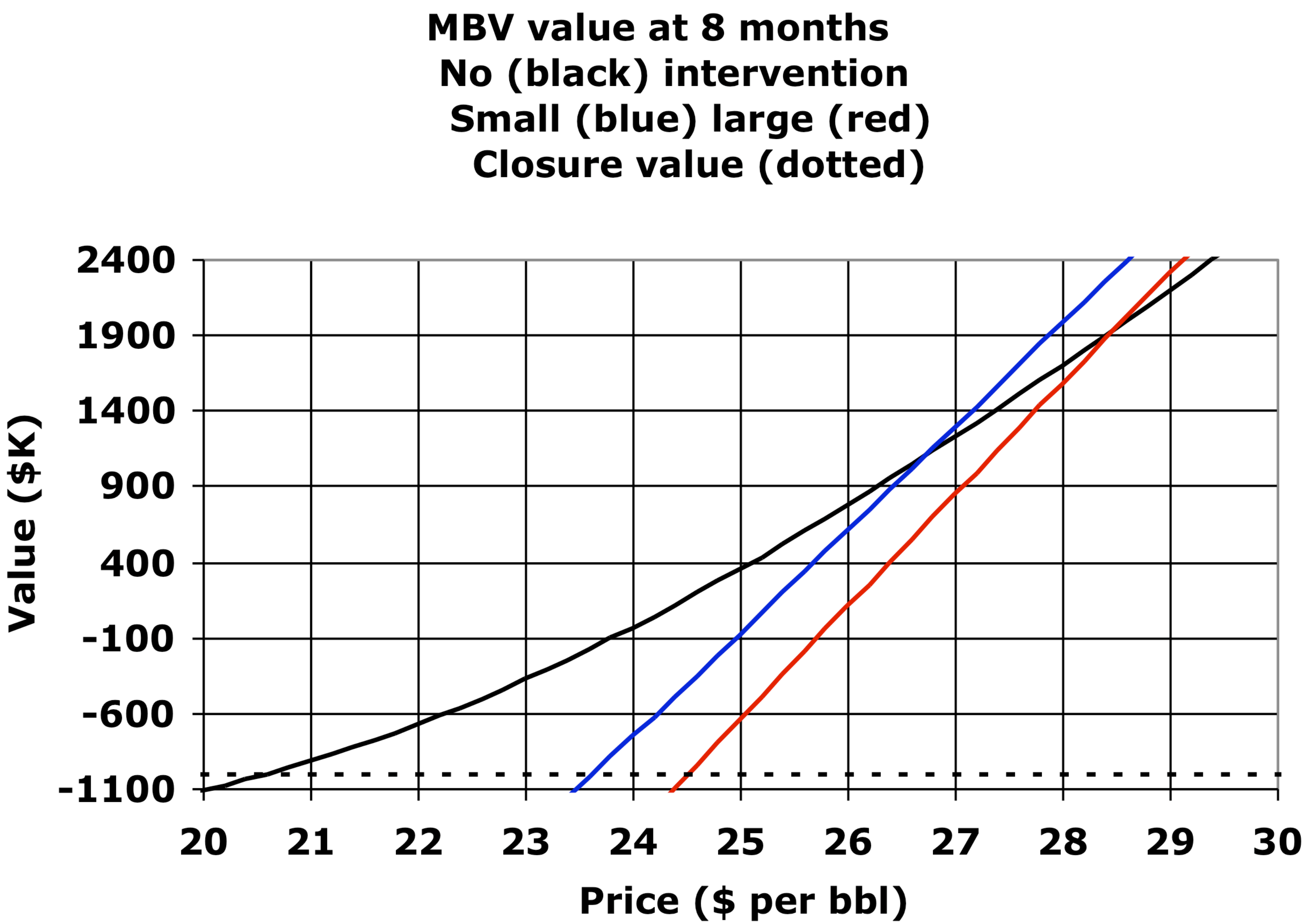

DCF value at 8 months
No (black) intervention
Small (blue) large (red)
Closure value (dotted)
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
-1100
Value ($K)
19.5
20.0
20.5
21.0
21.5
22.0
22.5
Price ($ per bbl)

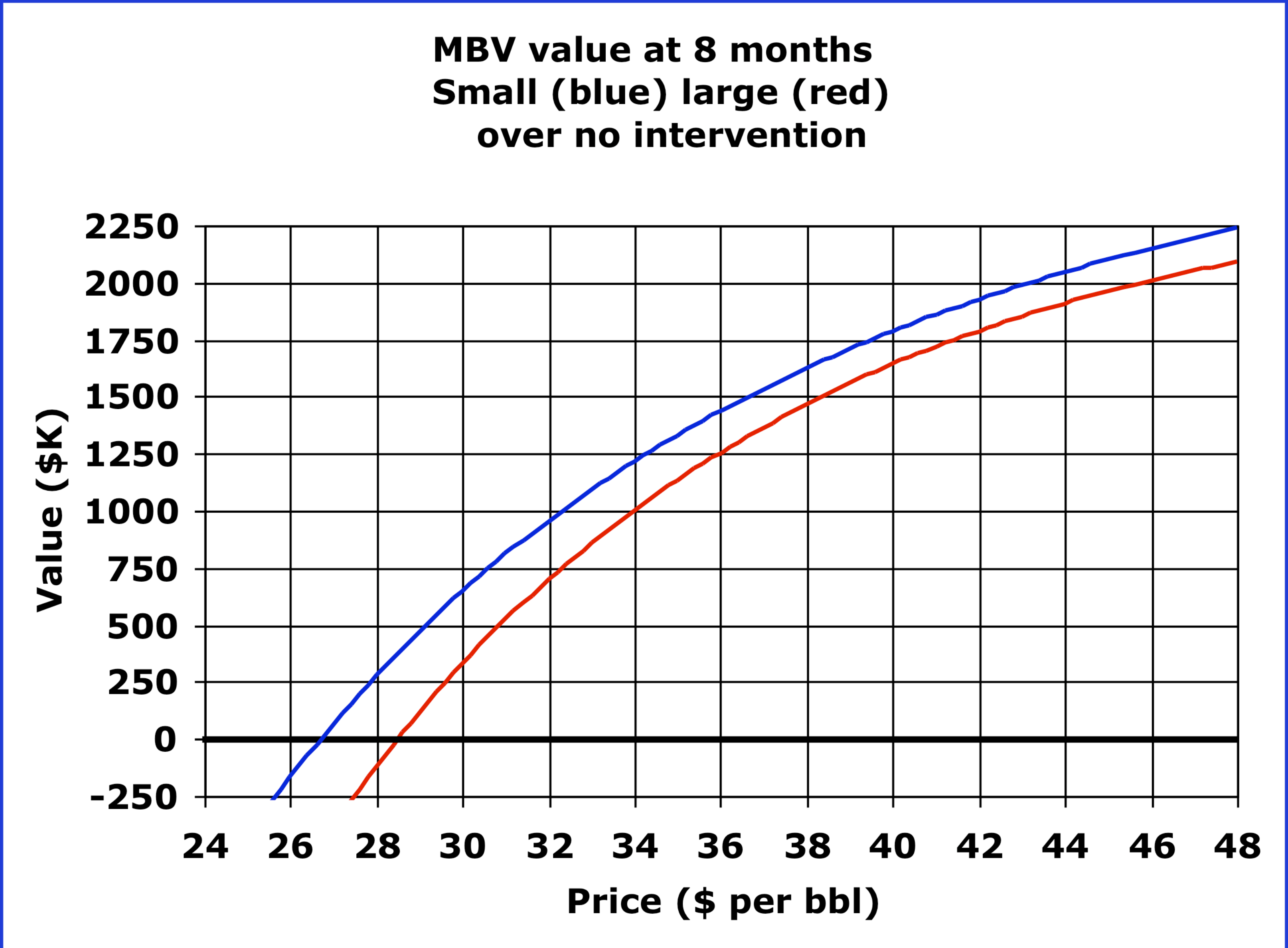

DCF value at 8 months
Small (blue) large (red)
over no intervention
3500
3000
2500
2000
1500
1000
500
0
-500
Value ($K)
20 22 24 26 28 30 32 34 36 38 40 42 44 46 48
Price ($ per bbl)

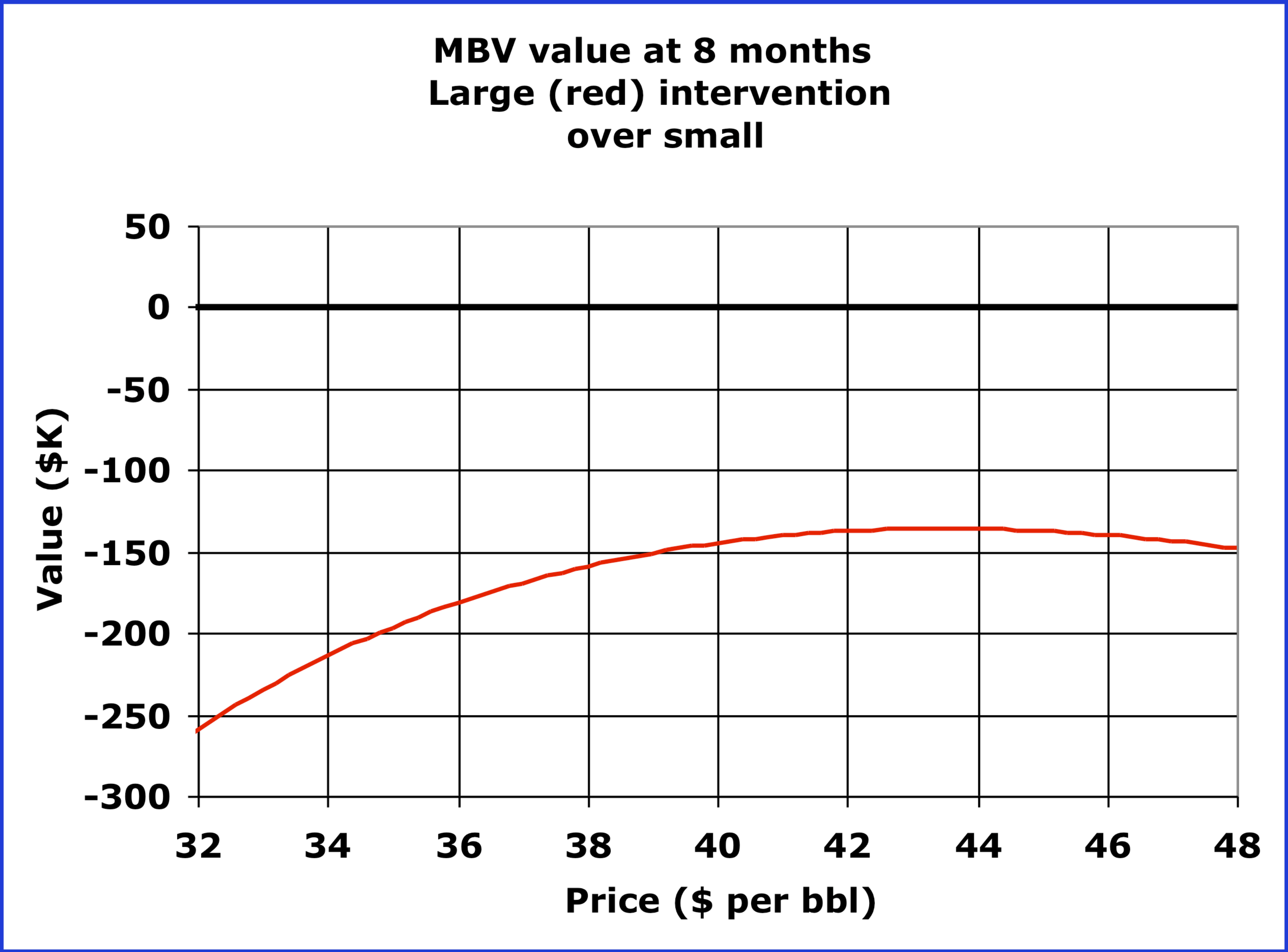

DCF value at 8 months
Large (red) intervention
over small
Value ($K)
400
300
200
100
0
-100
-200
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
Price ($ per bbl)

**MBV value at 8 months**
**No (black) intervention**
**Small (blue) large (red)**
**Closure value (dotted)**



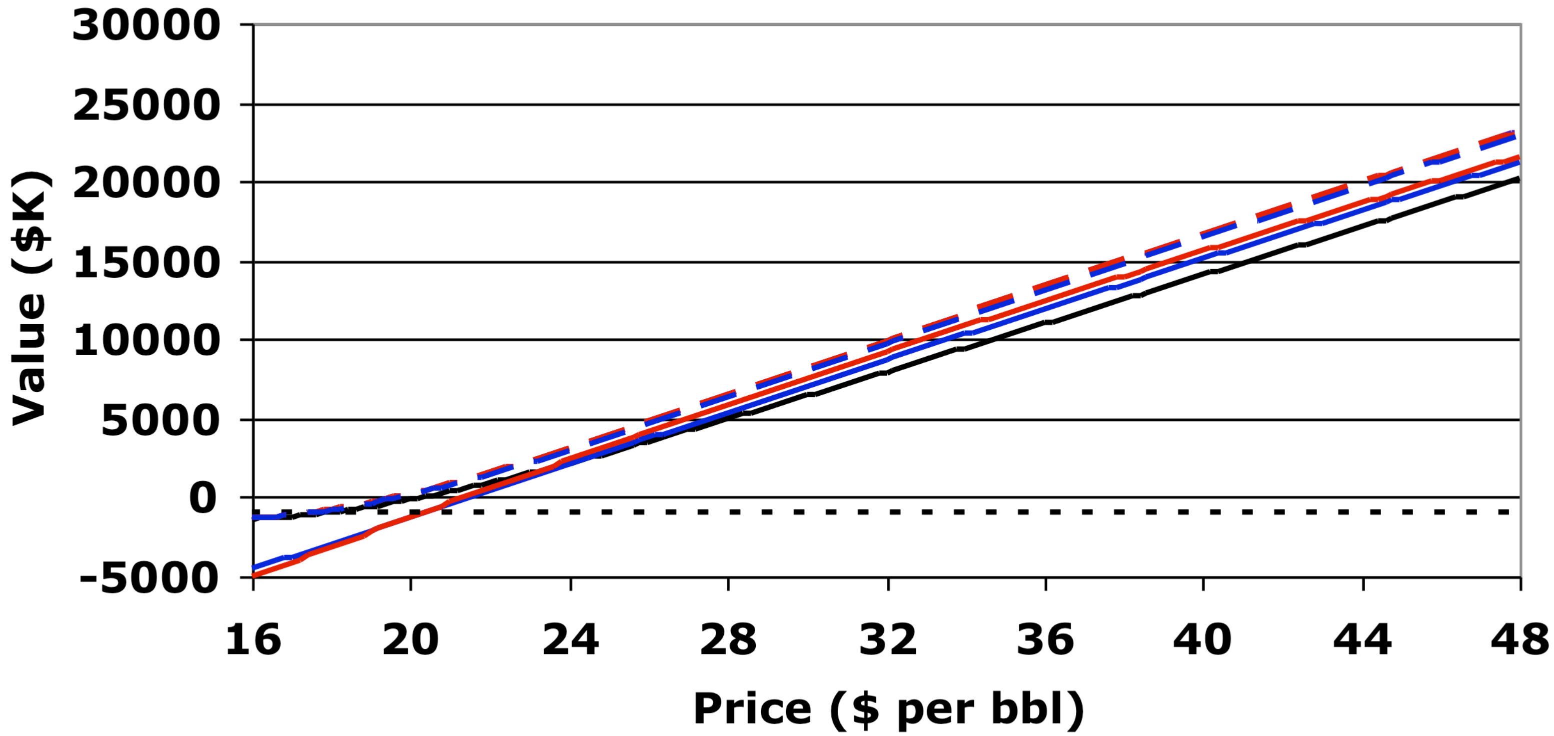

MBV value at 8 months
No (black) intervention
Small (blue) large (red)
Closure value (dotted)
2400
1900
1400
900
400
-100
-600
-1100
Value ($K)
20
21
22
23
24
25
26
27
28
29
30
Price ($ per bbl)


MBV value at 8 months
Small (blue) large (red)
over no intervention
2250
2000
1750
1500
1250
1000
750
500
250
0
-250
Value ($K)
24
26
28
30
32
34
36
38
40
42
44
46
48
Price ($ per bbl)

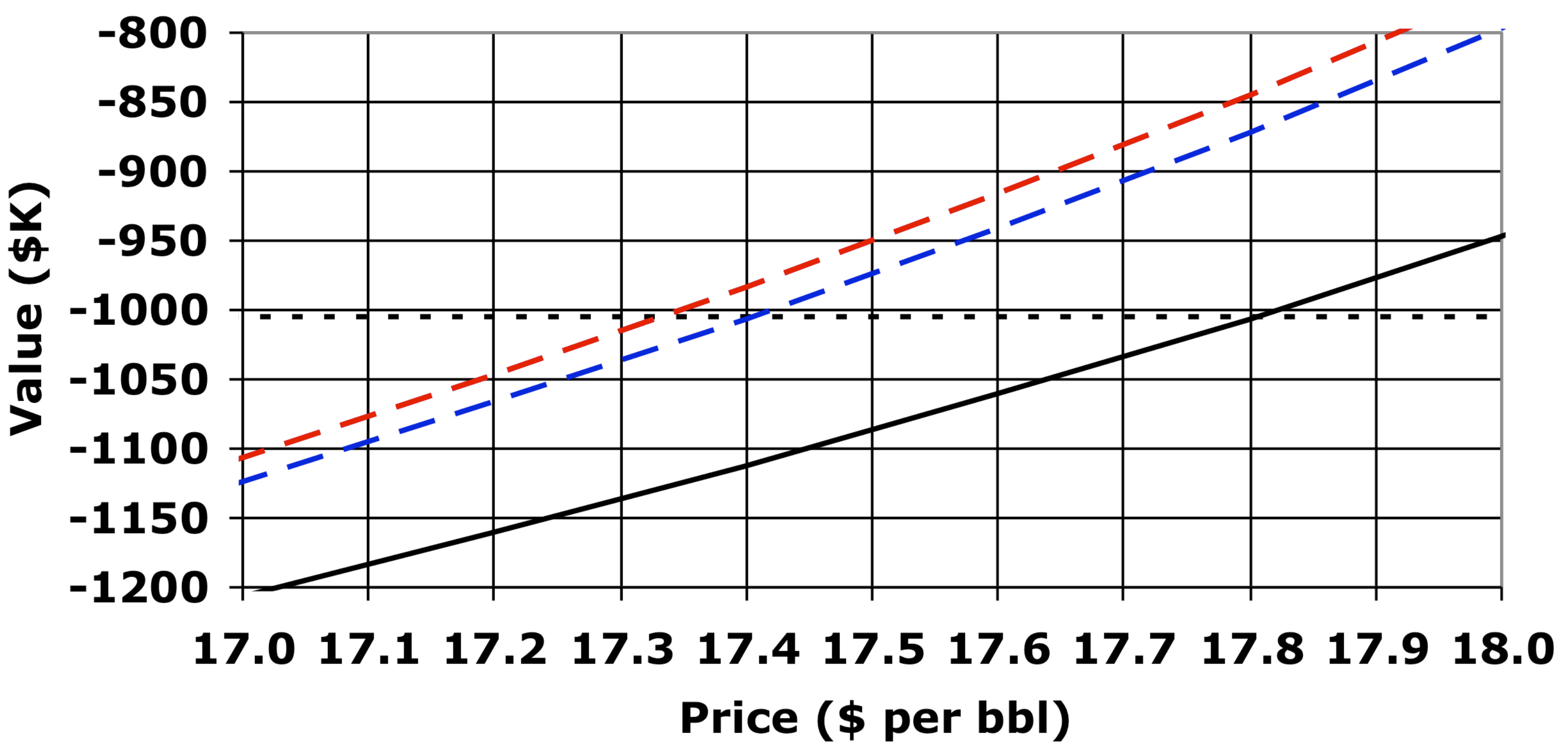


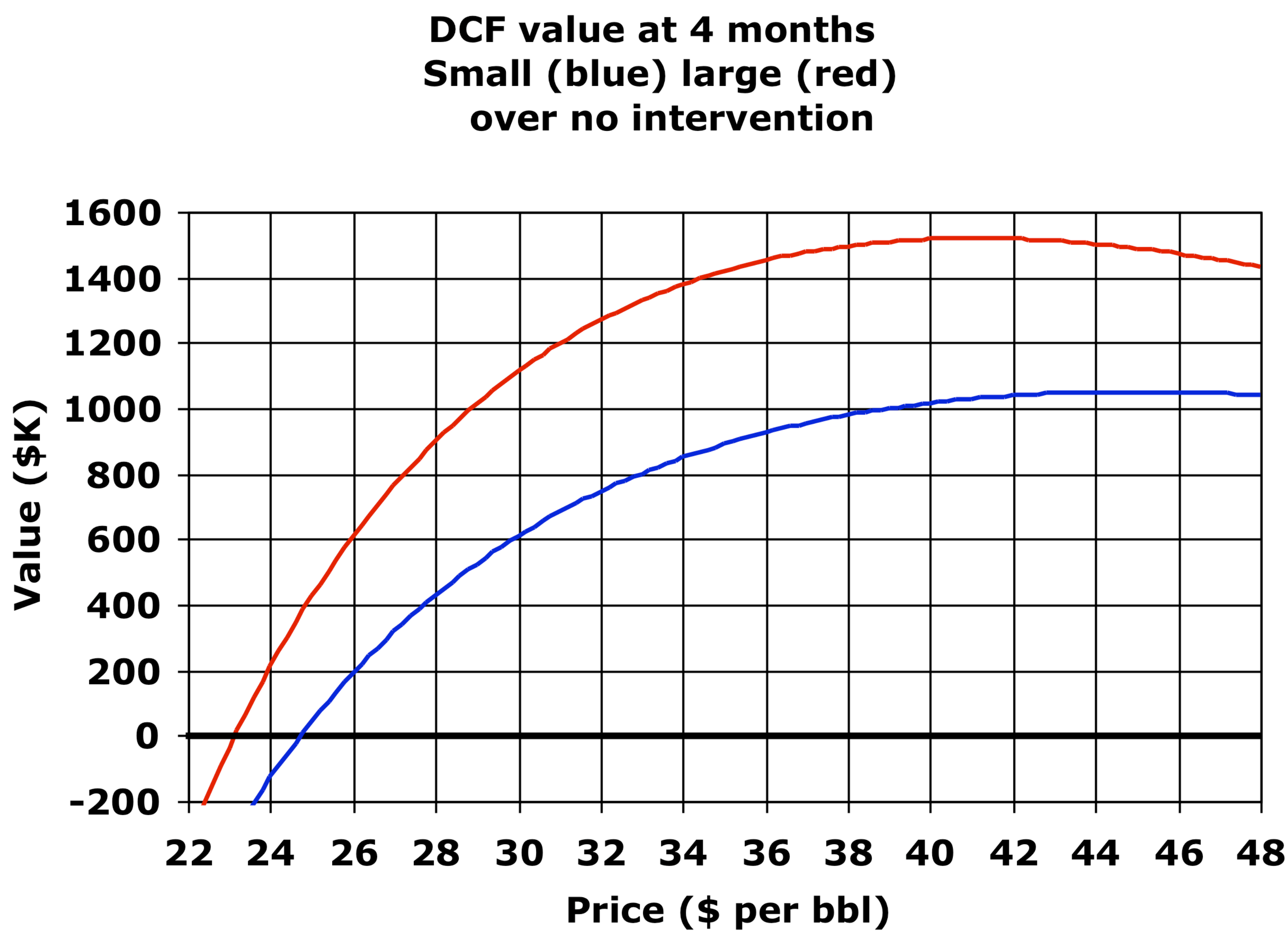
MBV value at 8 months
Large (red) intervention
over small
Value ($K)
50
0
-50
-100
-150
-200
-250
-300
32
34
36
38
40
42
44
46
48
Price ($ per bbl)

**DCF value at 4 months**
**No (black) intervention**
**Small (blue) large (red)**
**Continue (dashed) with small (blue) large (red)**
**both (purple) allowed at 8 months**
**Closure value (dotted)**

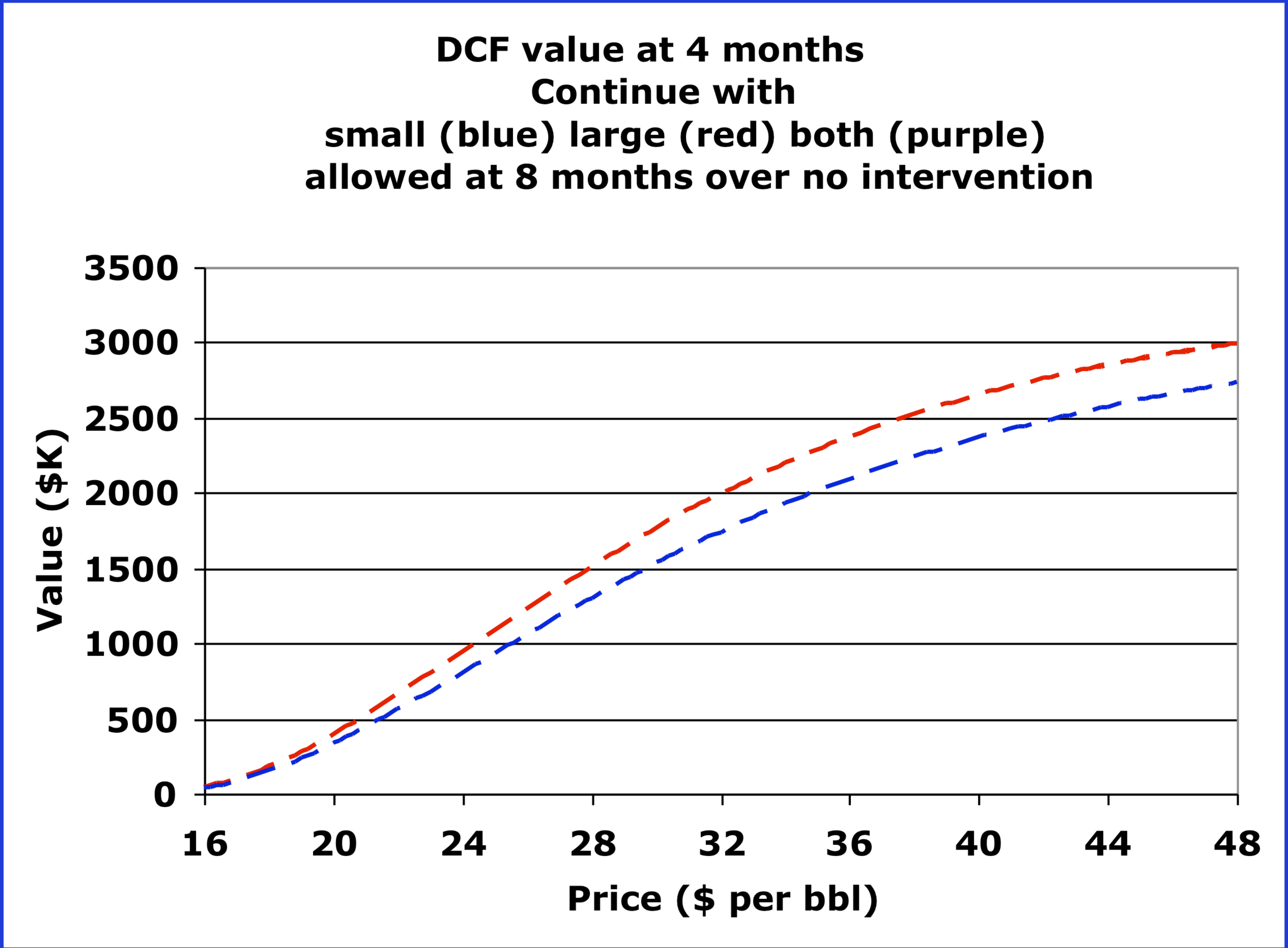


**DCF value at 4 months**
**No (black) intervention**
**Small (blue) large (red)**
**Continue (dashed) with small (blue) large (red)**
**both (purple) allowed at 8 months**
**Closure value (dotted)**

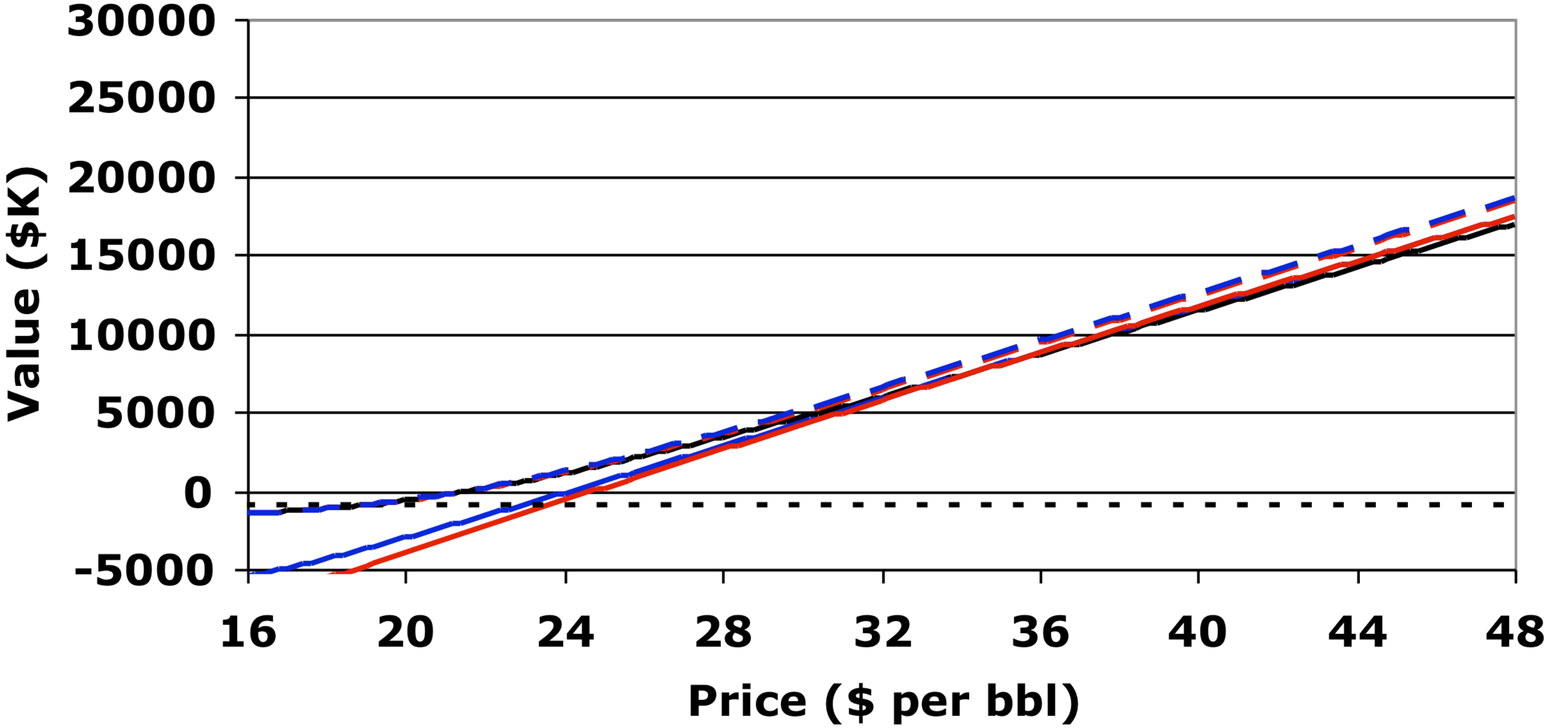


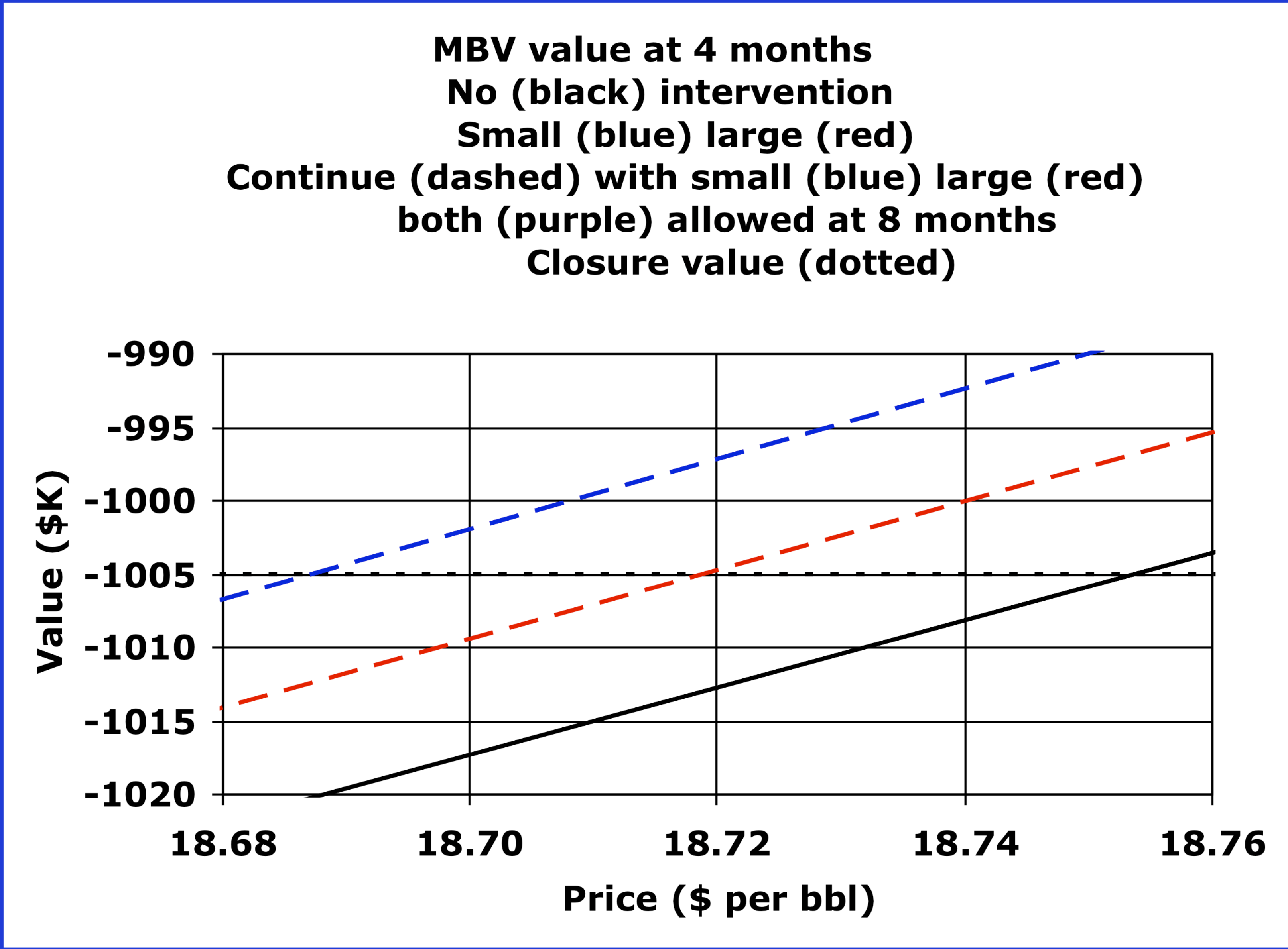


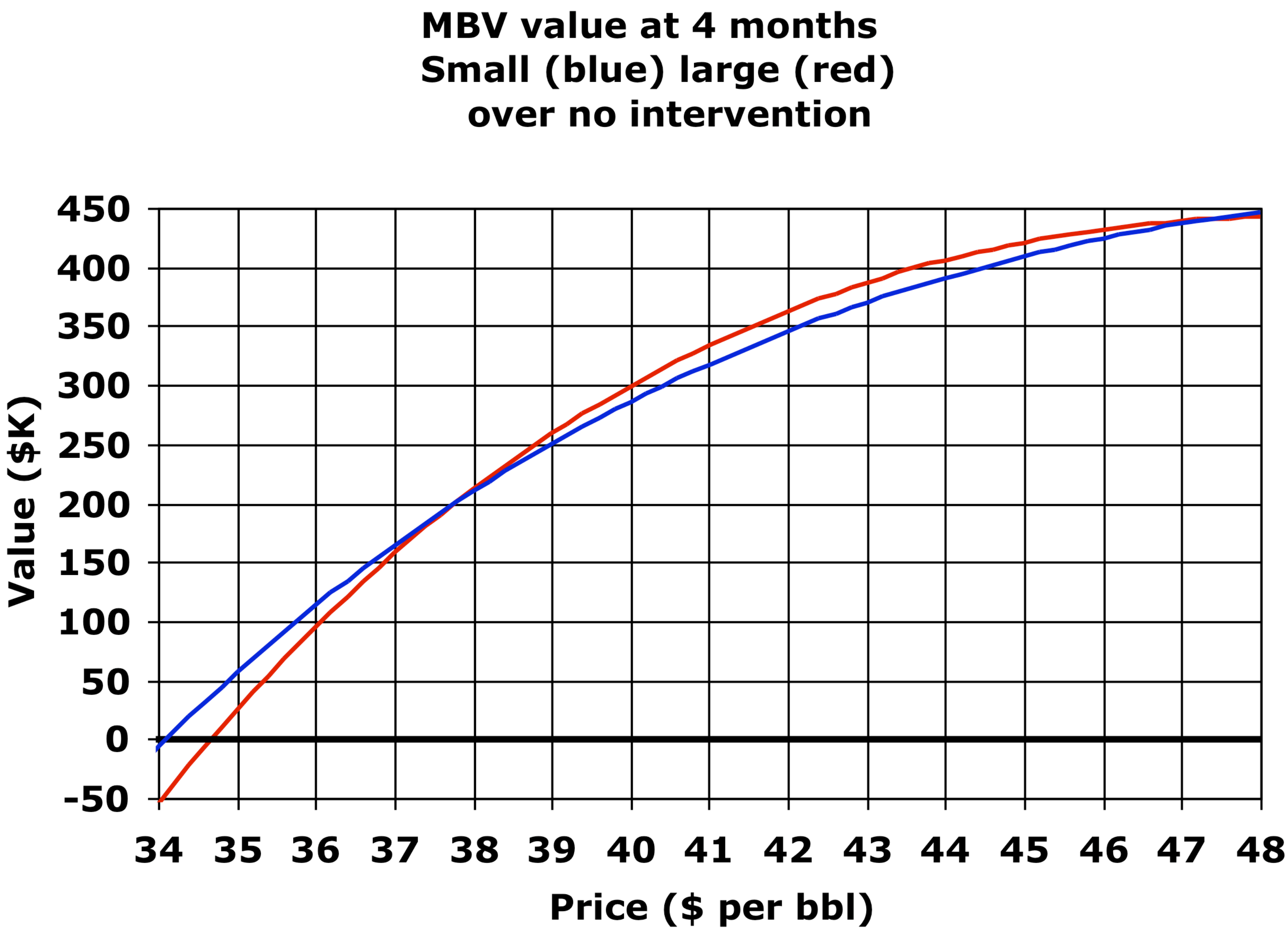
DCF value at 4 months
Small (blue) large (red)
over no intervention
Value ($K)
1600
1400
1200
1000
800
600
400
200
0
-200
22
24
26
28
30
32
34
36
38
40
42
44
46
48
Price ($ per bbl)

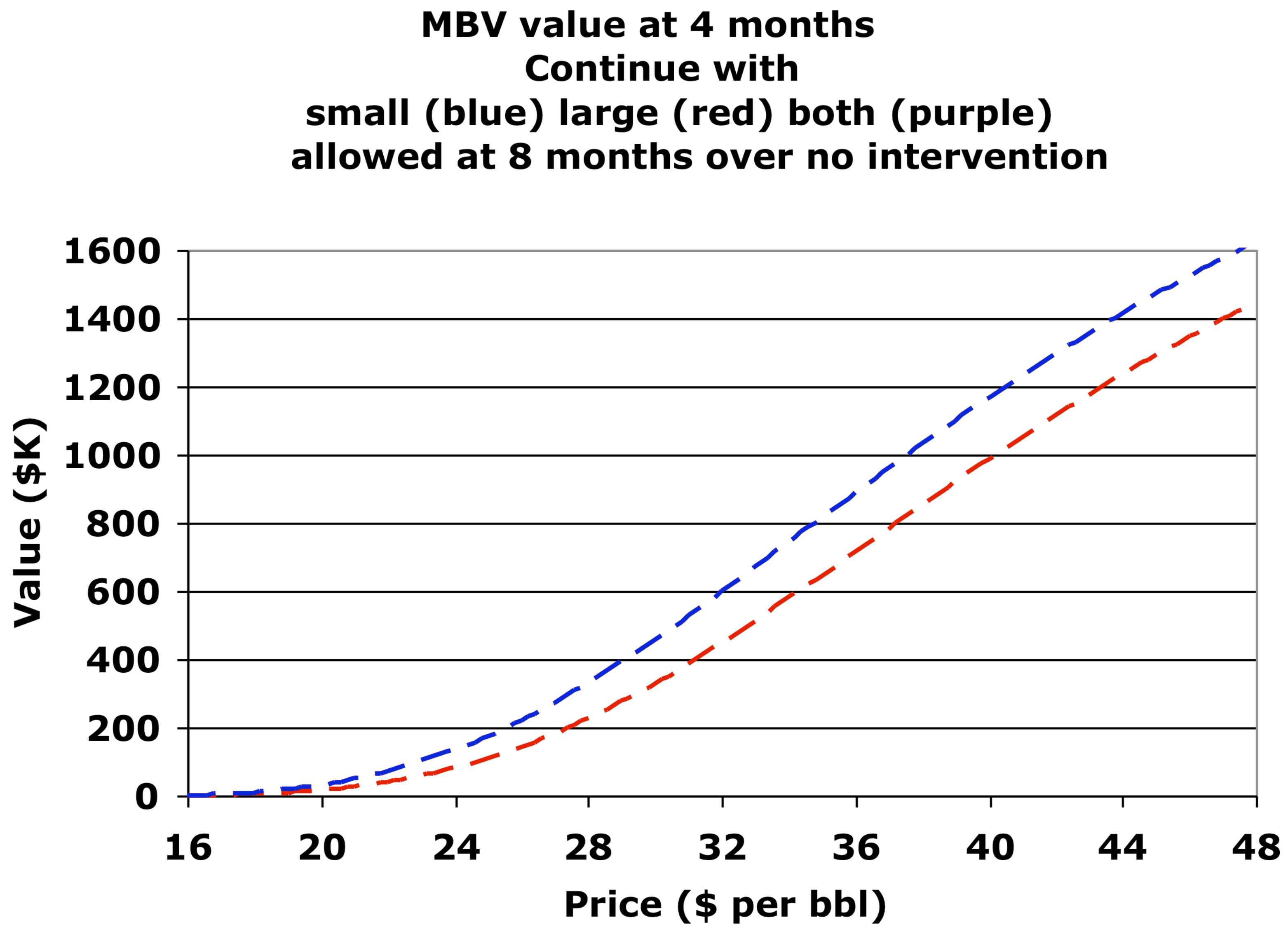

DCF value at 4 months
Continue with
small (blue) large (red) both (purple)
allowed at 8 months over no intervention
3500
3000
2500
2000
1500
1000
500
0
Value ($K)
16
20
24
28
32
36
40
44
48
Price ($ per bbl)

**MBV value at 4 months**
**No (black) intervention**
**Small (blue) large (red)**
**Continue (dashed) with small (blue) large (red)**
**both (purple) allowed at 8 months**
**Closure value (dotted)**




MBV value at 4 months
No (black) intervention
Small (blue) large (red)
Continue (dashed) with small (blue) large (red)
both (purple) allowed at 8 months
Closure value (dotted)
-990
-995
-1000
-1005
-1010
-1015
-1020
Value ($K)
18.68
18.70
18.72
18.74
18.76
Price ($ per bbl)


MBV value at 4 months
Small (blue) large (red)
over no intervention
Value ($K)
450
400
350
300
250
200
150
100
50
0
-50
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
Price ($ per bbl)


MBV value at 4 months
Continue with
small (blue) large (red) both (purple)
allowed at 8 months over no intervention
1600
1400
1200
1000
800
600
400
200
0
Value ($K)
16
20
24
28
32
36
40
44
48
Price ($ per bbl)

# Optimal DCF choices at 4 and 8 months

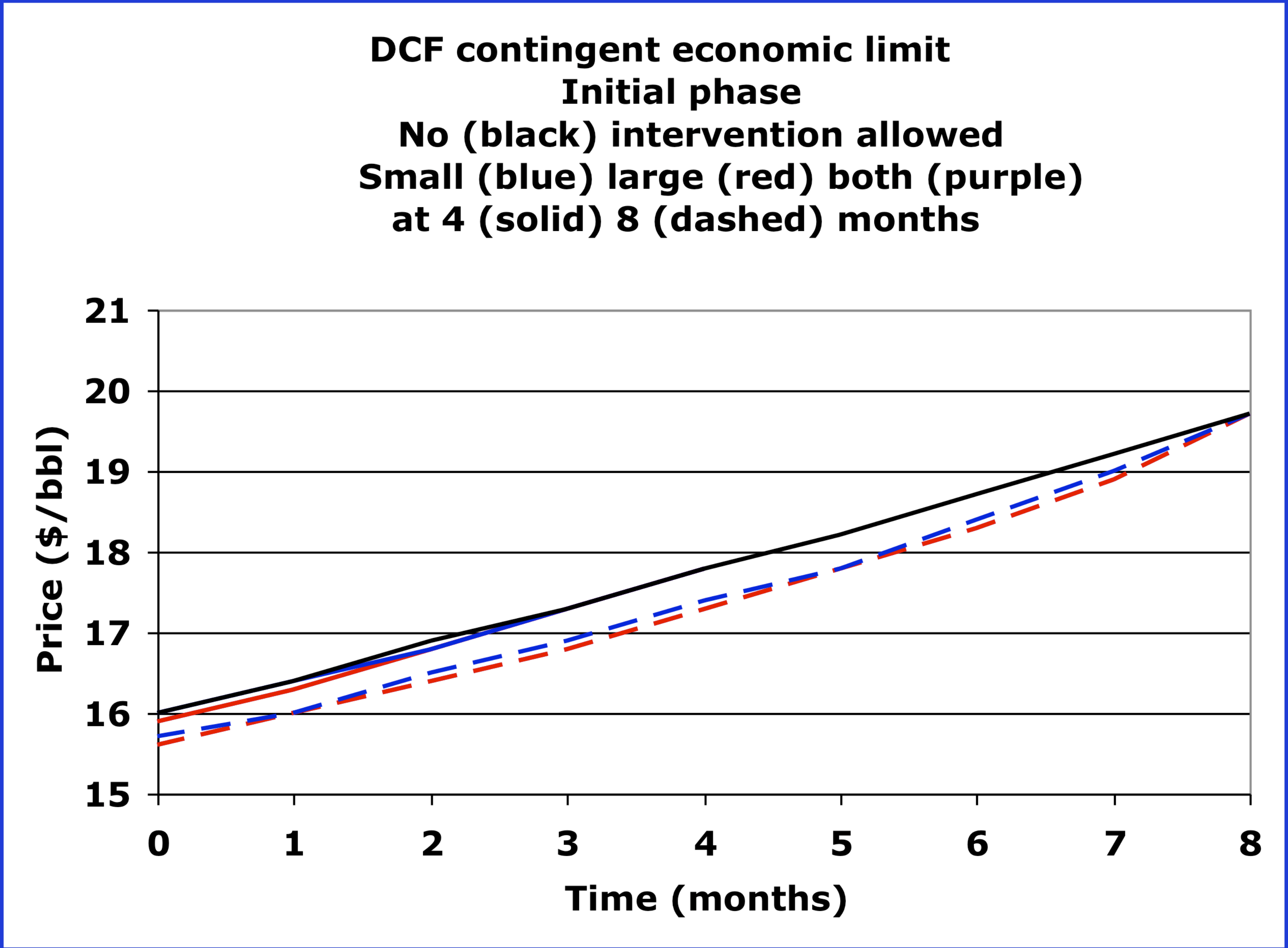
| Avail Int | Act | Bound | Act | Bound | Act | Bound | Act | Bound | Act |
|---|---|---|---|---|---|---|---|---|---|
| 4 months | | | | | | | | | |
| X-LS | C | 17.4 | N | | N | | N | | N |
| X-L | C | 17.4 | N | | N | | N | | N |
| X-S | C | 17.5 | N | | N | | N | | N |
| LS | C | 17.9 | N | 23.2 | L | | L | 66.4 | S |
| L | C | 17.9 | N | 23.2 | L | | L | 79.6 | N |
| S | C | 17.9 | N | 24.8 | S | | S | | S |
| 8 months | | | | | | | | | |
| X-LS | C | 19.8 | N | 22.0 | L | | L | 61.4 | S |
| X-L | C | 19.8 | N | 22.0 | L | | L | | L |
| X-S | C | 19.8 | N | 22.1 | S | | S | | S |

| | |
|---|---|
| Avail Int | Set of available interventions |
| Bound | Price boundary ($/bbl) |
| Act | Action between price boundaries |
| L | Large intervention |
| S | Small intervention |
| N | No intervention |
| C | Closure |
| X | Any of LS, L, S, N |

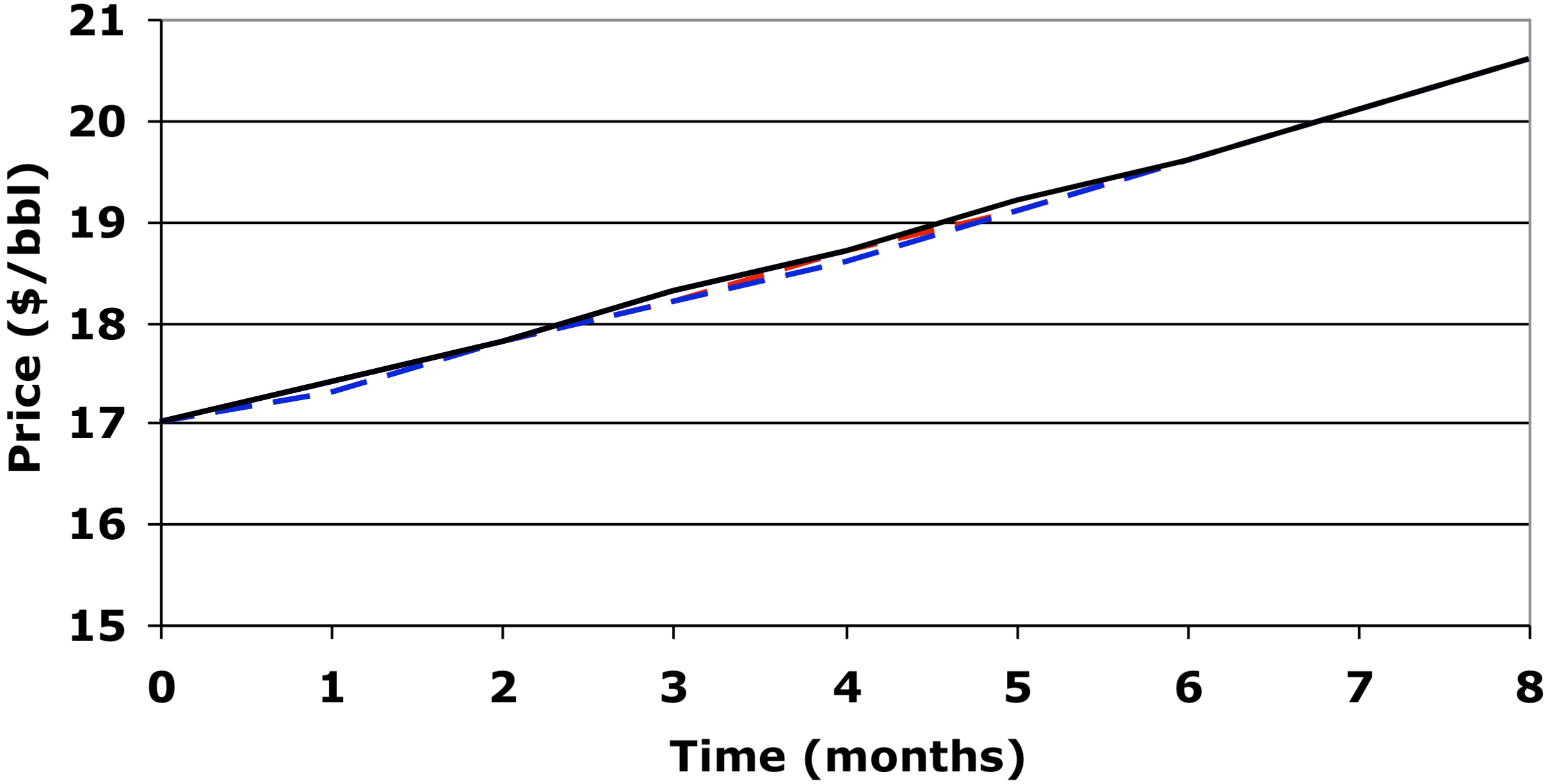
# Optimal MBV choices at 4 and 8 months

| Avail Int | Act | Bound | Act | Bound | Act | Bound | Act | Bound | Act |
|---|---|---|---|---|---|---|---|---|---|
| 4 months | | | | | | | | | |
| X-LS | C | 18.7 | N | | N | | N | | N |
| X-L | C | 18.8 | N | | N | | N | | N |
| X-S | C | 18.7 | N | | N | | N | | N |
| LS | C | 18.8 | N | 34.2 | S | 37.8 | L | 47.4 | S |
| L | C | 18.8 | N | 34.7 | L | | L | 69.1 | N |
| S | C | 18.8 | N | 34.2 | S | | S | | S |
| 8 months | | | | | | | | | |
| X-LS | C | 20.7 | N | 26.8 | S | | S | | S |
| X-L | C | 20.7 | N | 28.5 | L | | L | | L |
| X-S | C | 20.7 | N | 26.8 | S | | S | | S |

| | |
|---|---|
| Avail Int | Set of available interventions |
| Bound | Price boundary ($/bbl) |
| Act | Action between price boundaries |
| L | Large intervention |
| S | Small intervention |
| N | No intervention |
| C | Closure |
| X | Any of LS, L, S, N |


DCF contingent economic limit
Initial phase
No (black) intervention allowed
Small (blue) large (red) both (purple)
at 4 (solid) 8 (dashed) months
Price ($/bbl)
21
20
19
18
17
16
15
0
1
2
3
4
5
6
7
8
Time (months)

**MBV contingent economic limit**
**Initial phase**
**No (black) intervention allowed**
**Small (blue) large (red) both (purple)**
**at 4 (solid) 8 (dashed) months**



# Comments

10% DCF favours larger later interventions

Overvalues revenues out to 34 months

Undervalues all costs, more the later they occur, including intervention cost

At high prices, less intervention is relatively favoured

Loss of oil in place comparatively more important than cost reduction

At low prices, less intervention is relatively favoured

Less life extension from intervention to justify intervention cost - even less so under MBV

# Comments cont'd

Either 8 month intervention dominates
both 4 month interventions (in both DCF and MBV)

Large interventions dominate small in DCF
for all but highest prices in price range examined

Small 8 month dominates large in MBV
in price range examined

Small 4 month intervention dominates large in MBV
for all but highest prices in price range examined

# Intervention options

Determine economic limits for each intervention

Determine optimal policy for contingent decision
to intervene at 8 months (given none at 4 months)
and at 4 months given optimal decision at 8 months

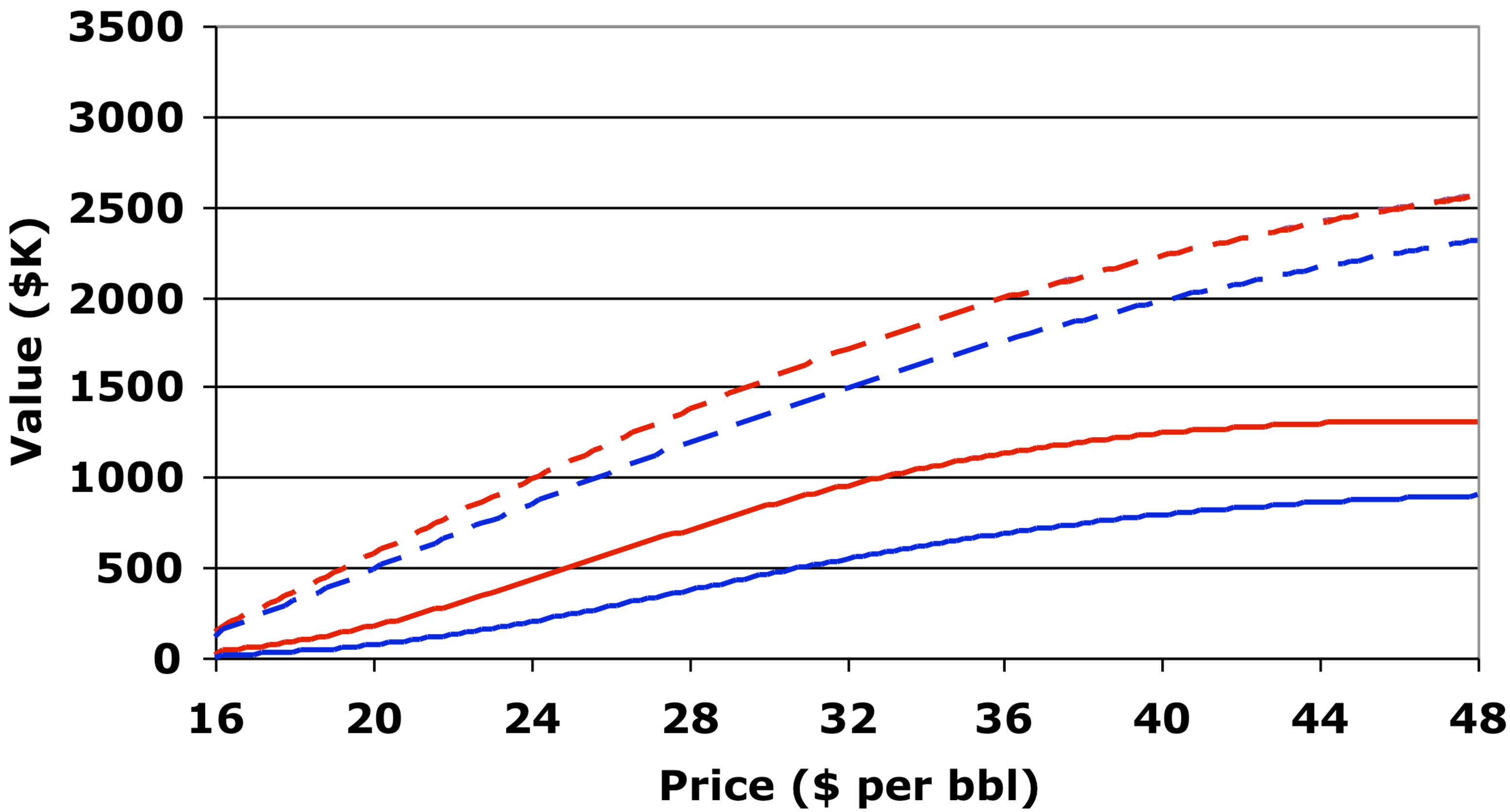
Determine value of contingent intervention options

Determine, for each current price, optimal policy for,
and value of, prespecified intervention options

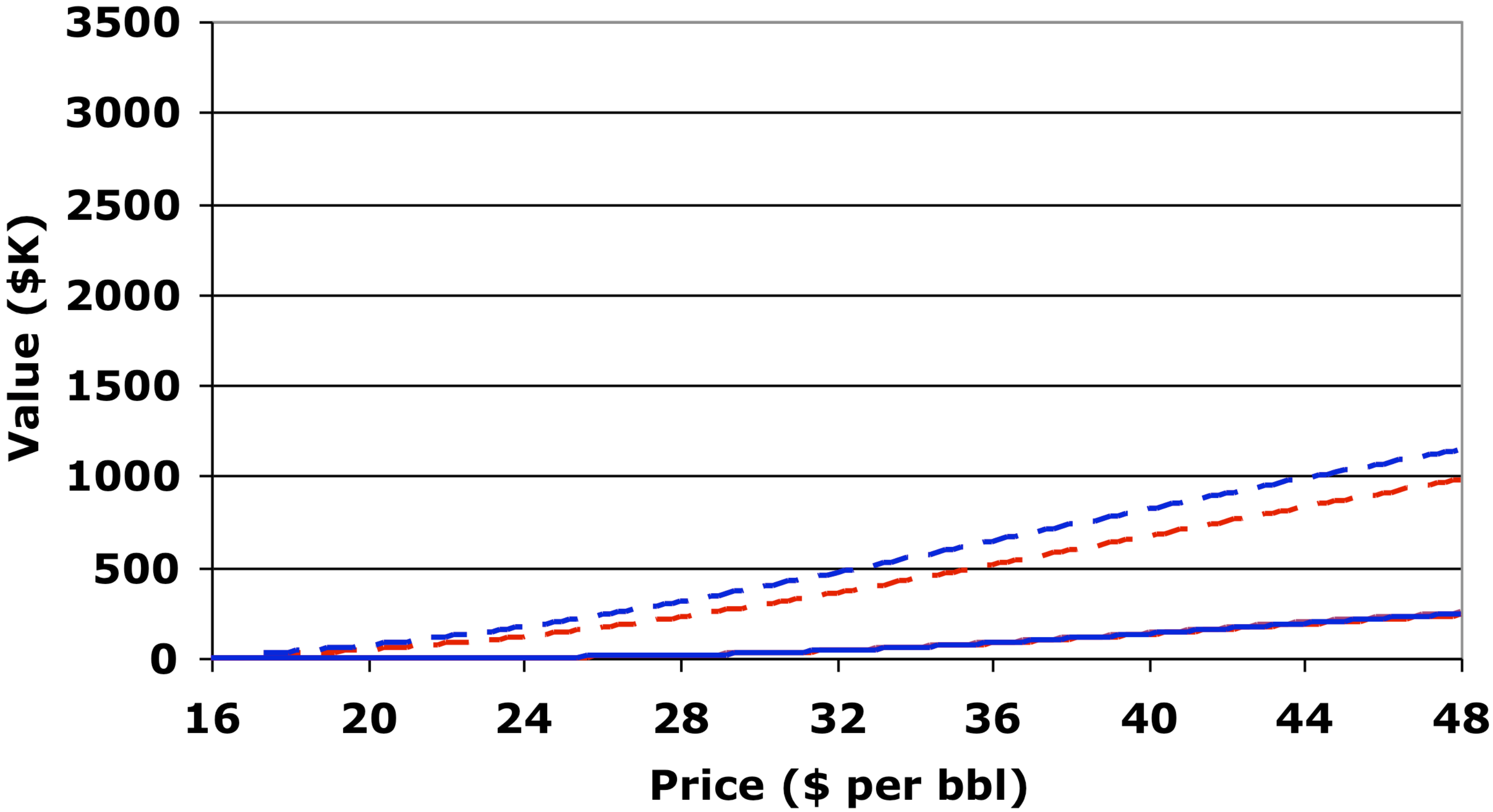
Determine value of contingent decision-making

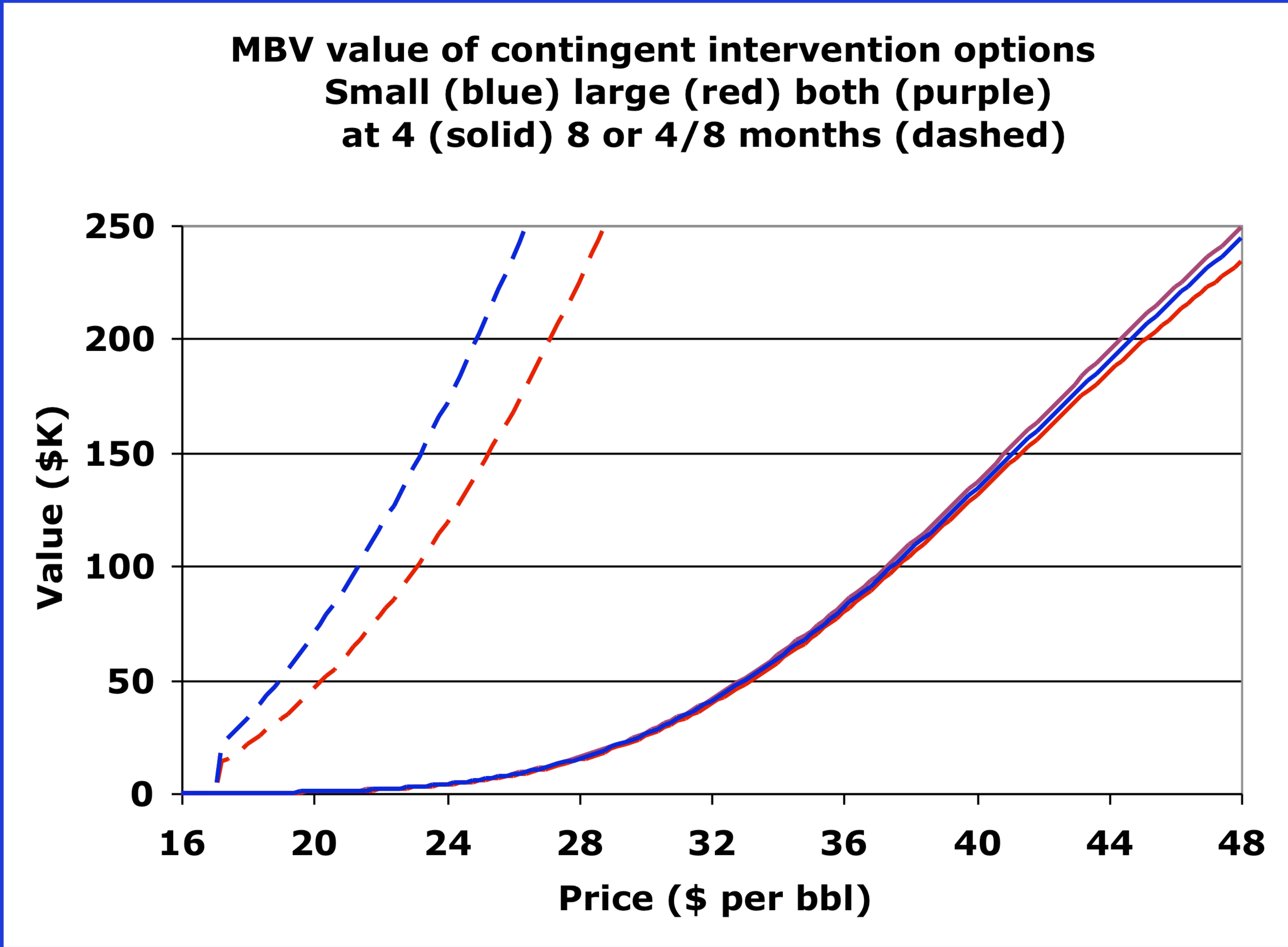
Determine value lost by following DCF policy

## DCF value of contingent intervention options
## Small (blue) large (red) both (purple)
## at 4 (solid) 8 or 4/8 months (dashed)



**MBV value of contingent intervention options Small (blue) large (red) both (purple) at 4 (solid) 8 or 4/8 months (dashed)**




MBV value of contingent intervention options
Small (blue) large (red) both (purple)
at 4 (solid) 8 or 4/8 months (dashed)
Value ($K)
250
200
150
100
50
0
16
20
24
28
32
36
40
44
48
Price ($ per bbl)

# Comments

Contingent intervention options valued
more highly by DCF

In price range examined,

DCF values access to late interventions more highly,
large interventions more than small at same time,
no advantage to access to early/small interventions

MBV values access to late interventions more highly,
small interventions more than large at same time,
some advantage to access to both interventions
when restricted to early interventions

# Intervention options

Determine economic limits for each intervention

Determine optimal policy for contingent decision
to intervene at 8 months (given none at 4 months)
and at 4 months given optimal decision at 8 months

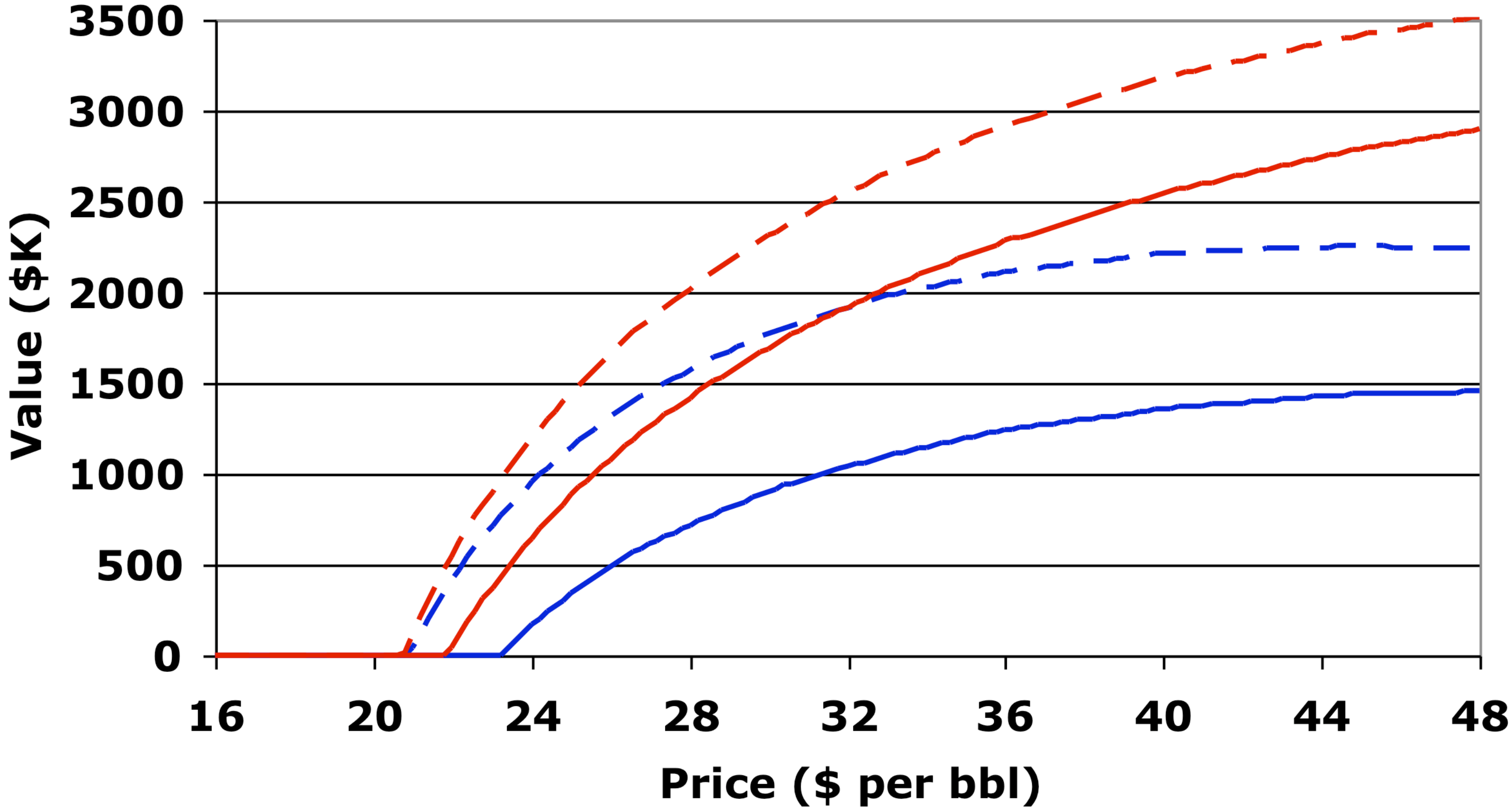
Determine value of contingent intervention options

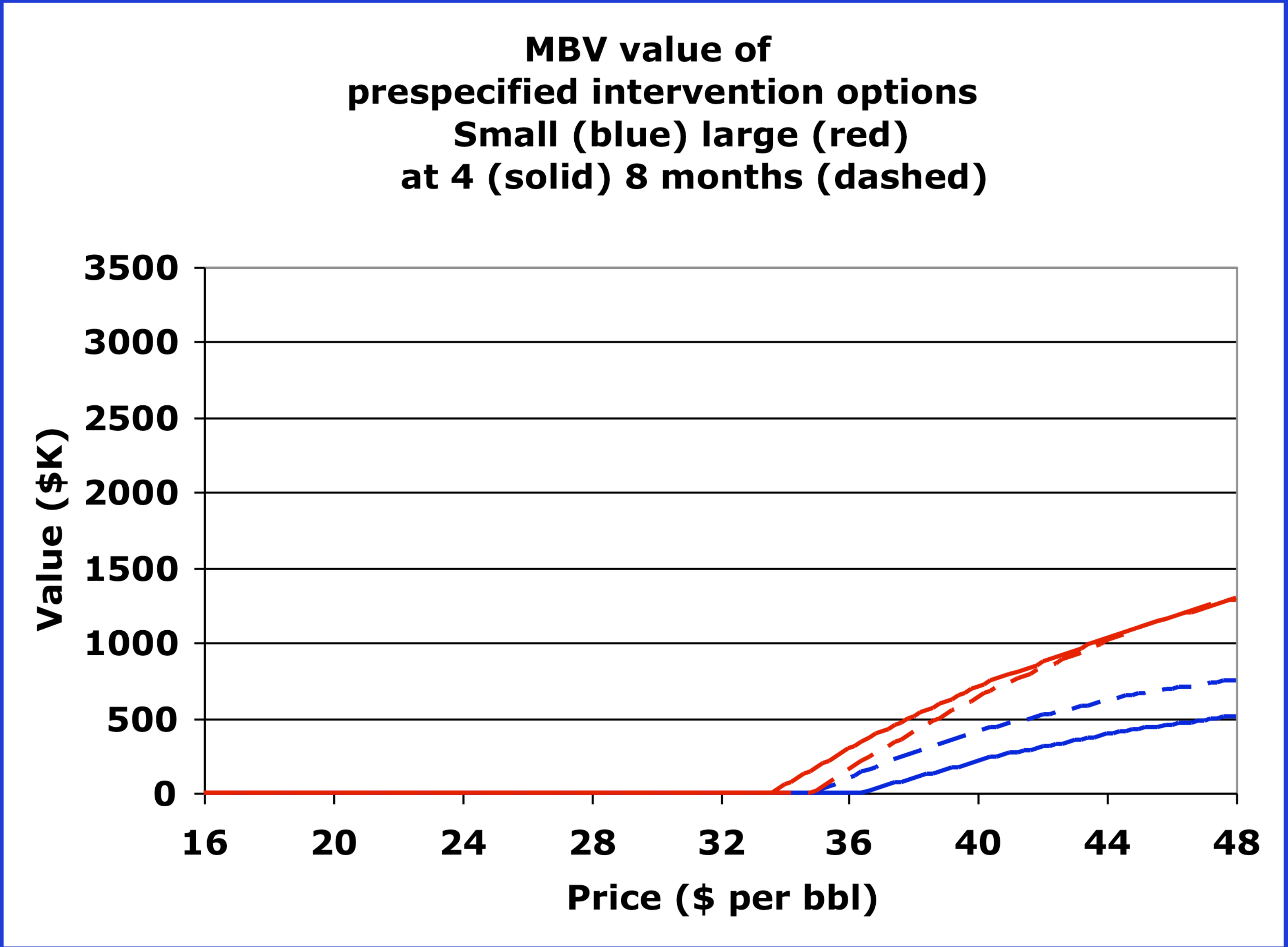
Determine, for each current price, optimal policy for,
and value of, prespecified intervention options

Determine value of contingent decision-making

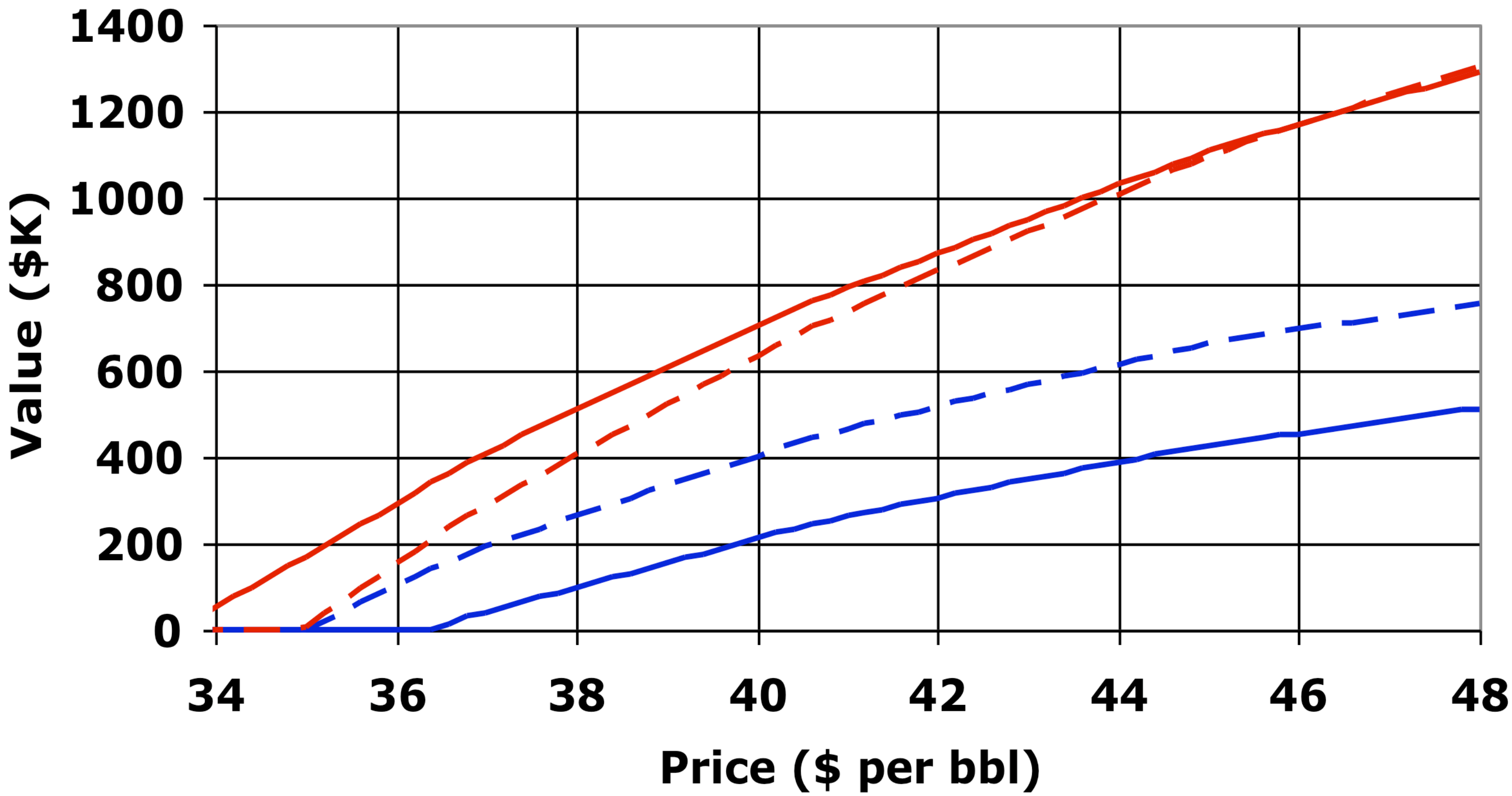
Determine value lost by following DCF policy

# DCF value of prespecified intervention options Small (blue) large (red) at 4 (solid) 8 months (dashed)




MBV value of
prespecified intervention options
Small (blue) large (red)
at 4 (solid) 8 months (dashed)
3500
3000
2500
2000
1500
1000
500
0
Value ($K)
16
20
24
28
32
36
40
44
48
Price ($ per bbl)

## MBV value of prespecified intervention options Small (blue) large (red) at 4 (solid) 8 months (dashed)



# Comments

Prespecified intervention options valued
more highly by DCF

In price range examined, lack of contingency
changes pattern of value of access to various options

DCF values access, at high prices,
to the early large intervention
more than late small intervention

MBV values access
to large interventions more than small,
and, at low prices, the early large intervention
more than late large intervention

# Intervention options

Determine economic limits for each intervention

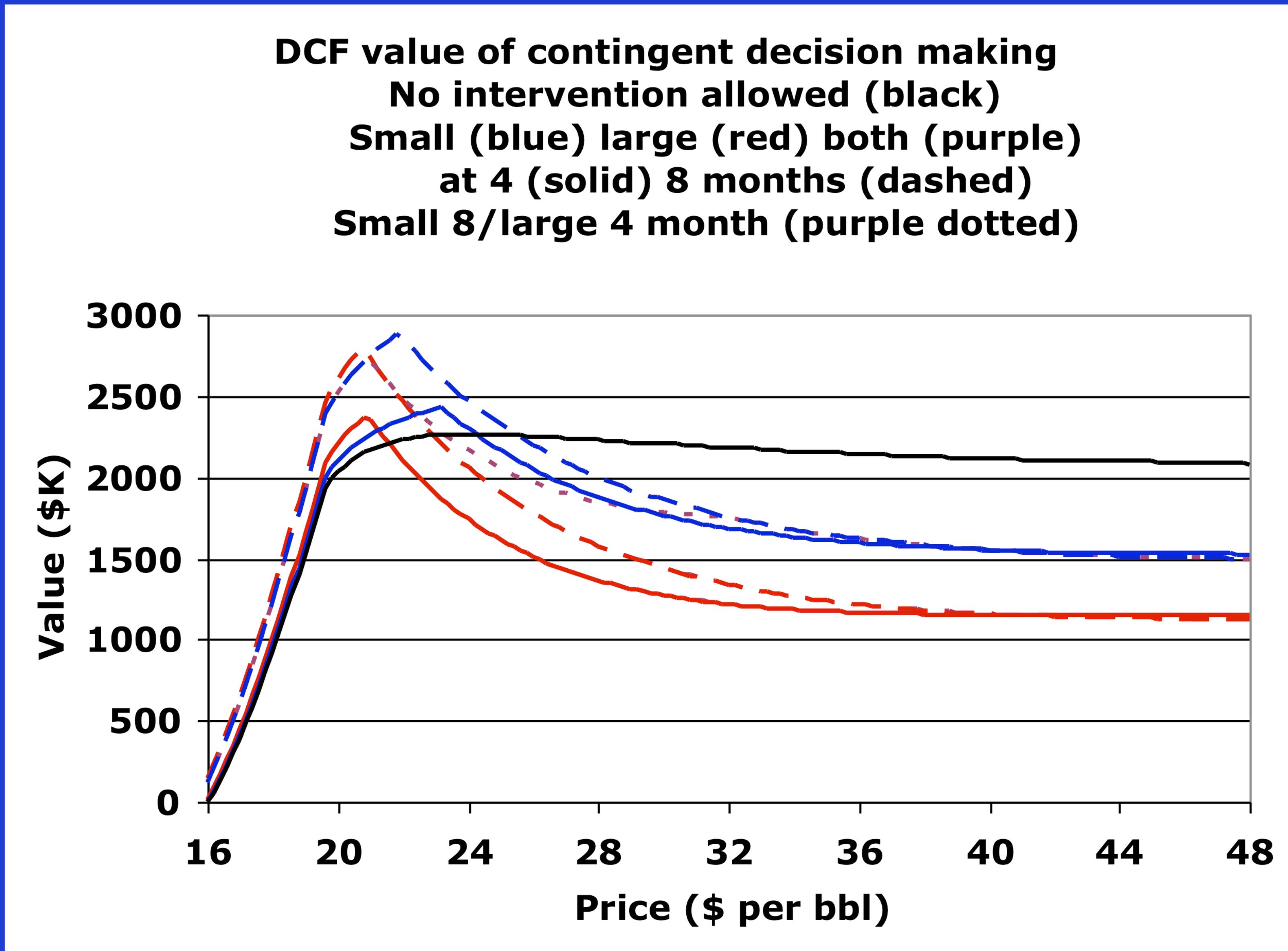
Determine optimal policy for contingent decision
to intervene at 8 months (given none at 4 months)
and at 4 months given optimal decision at 8 months

Determine value of contingent intervention options

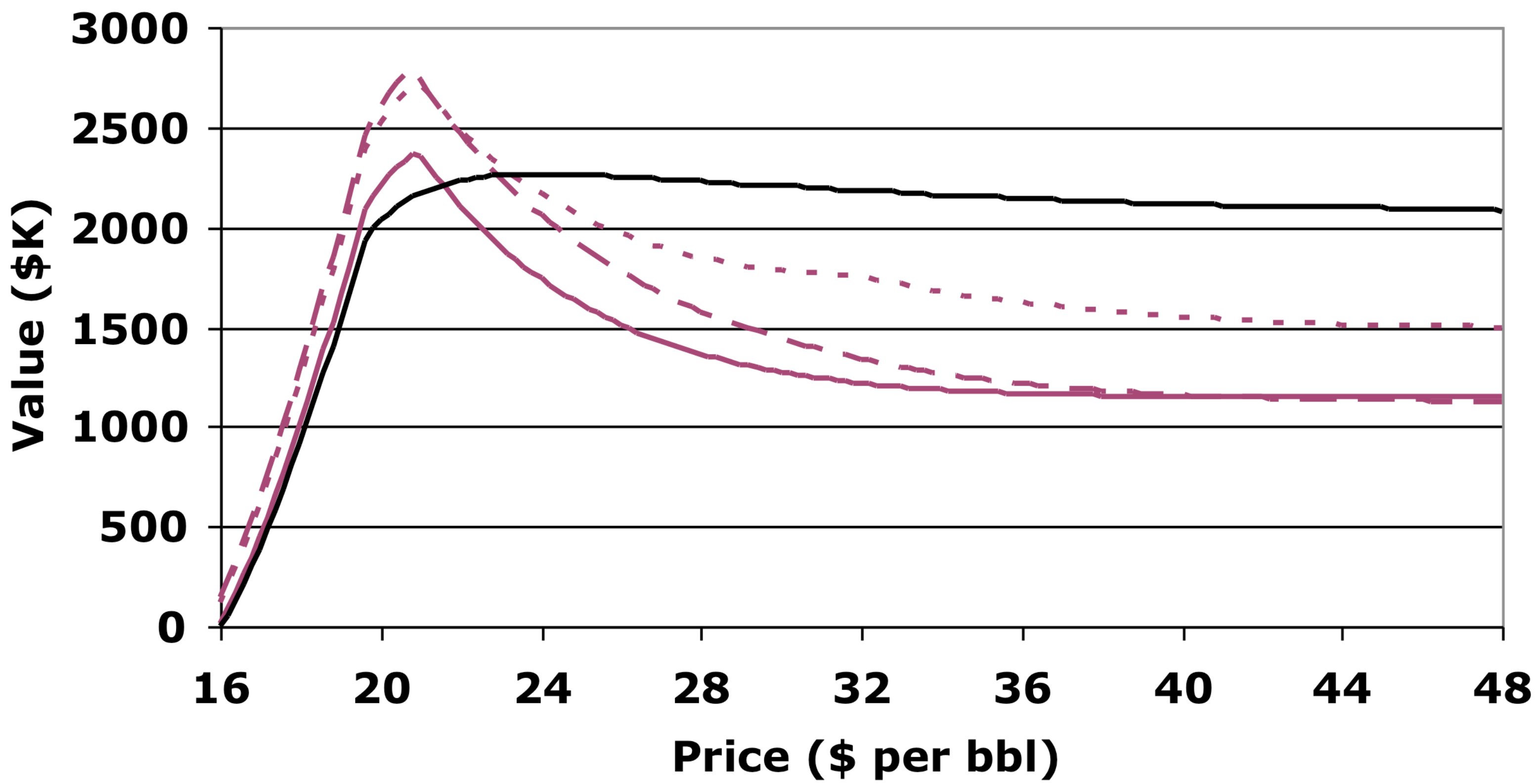
Determine, for each current price, optimal policy for,
and value of, prespecified intervention options

Determine value of contingent decision-making

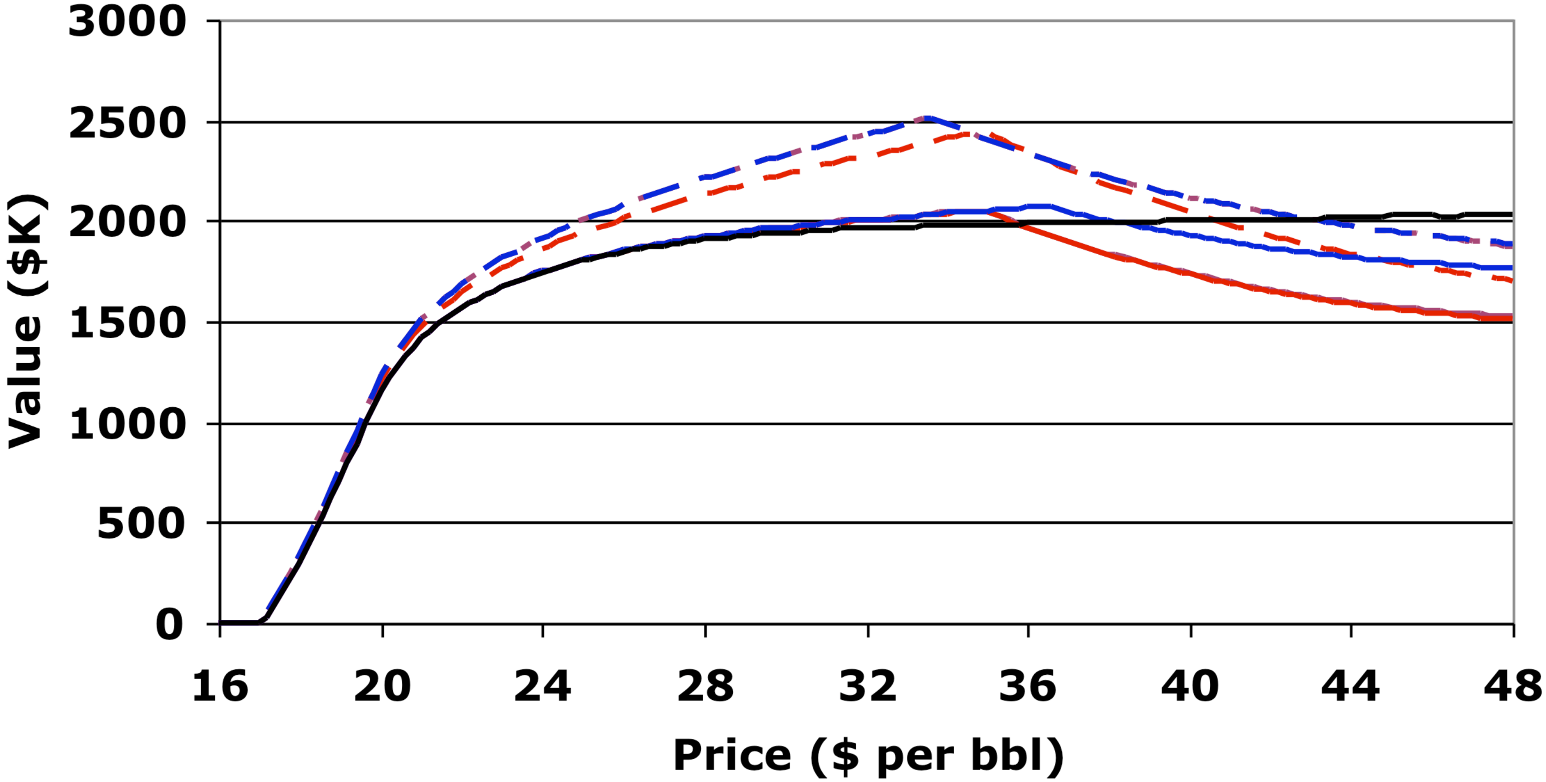
Determine value lost by following DCF policy


DCF value of contingent decision making
No intervention allowed (black)
Small (blue) large (red) both (purple)
at 4 (solid) 8 months (dashed)
Small 8/large 4 month (purple dotted)
3000
2500
2000
1500
1000
500
0
Value ($K)
16
20
24
28
32
36
40
44
48
Price ($ per bbl)

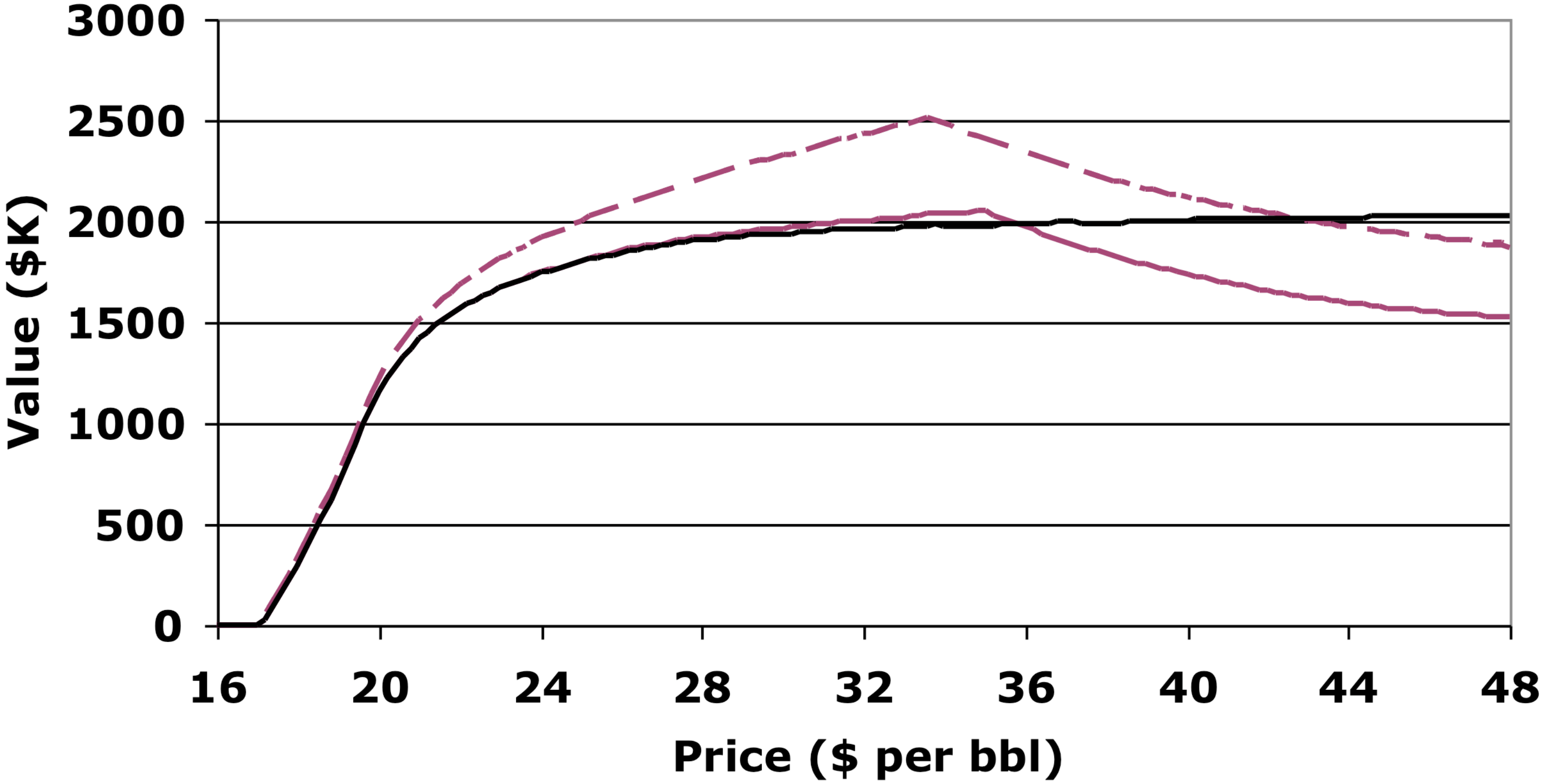
## DCF value of contingent decision-making
## Both at 4 (solid) 8 or 4/8 months (dashed)
## Small 8/large 4 month (dotted)



## MBV value of contingent decision making
No intervention allowed (black)
Small (blue) large (red) both (purple)
at 4 (solid) 8 months (dashed)
Small 8/large 4 month (purple dotted)



**MBV value of of contingent decision-making**
**Both at 4 (solid) 8 or 4/8 months (dashed)**
**Small 8/large 4 month (dotted)**



# Comments

Adding the possibility of intervention
does not greatly affect
the incremental value of contingent decision-making

Complex dependence on type of intervention allowed

# Intervention options

Determine economic limits for each intervention

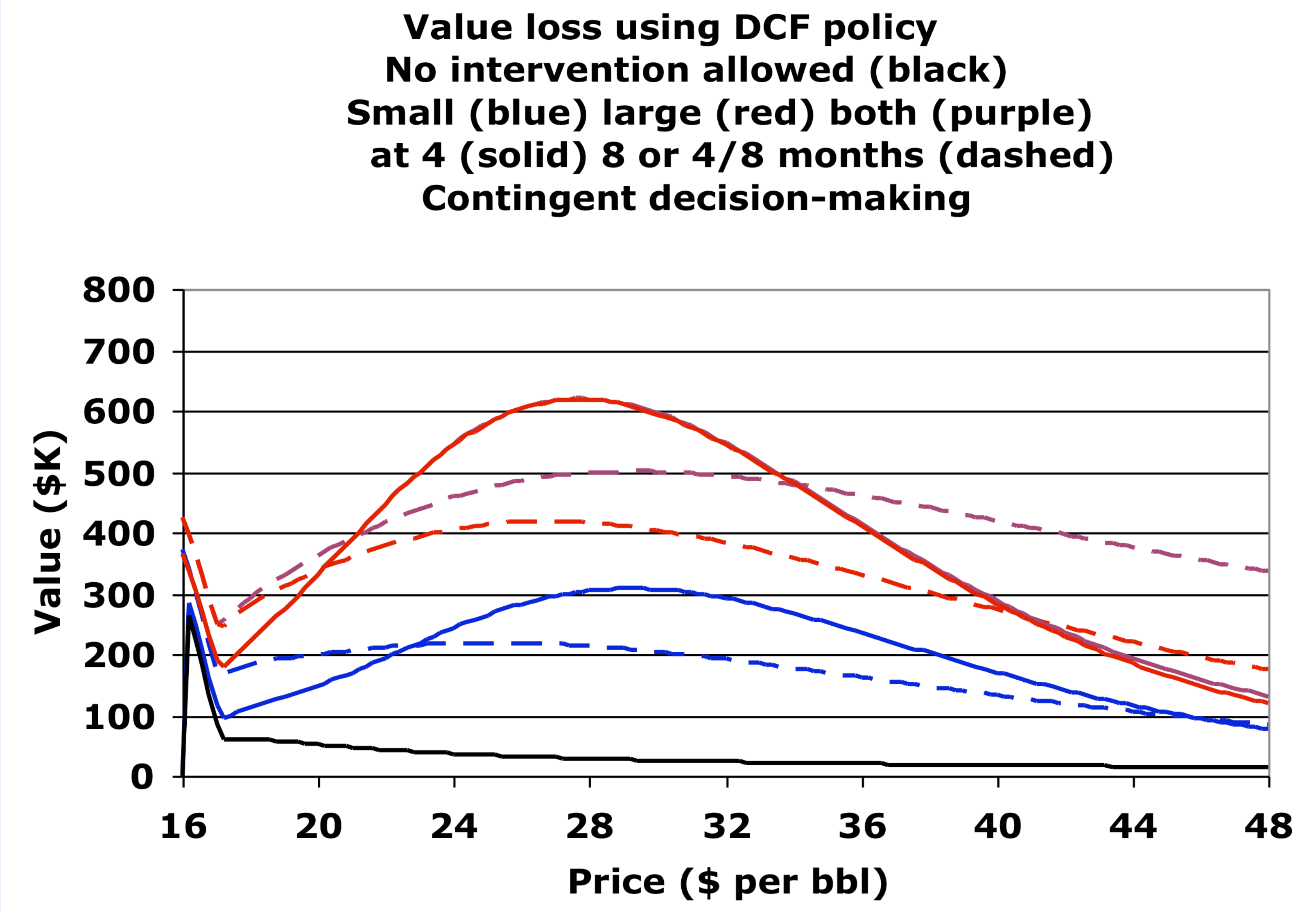
Determine optimal policy for contingent decision
to intervene at 8 months (given none at 4 months)
and at 4 months given optimal decision at 8 months

Determine value of contingent intervention options

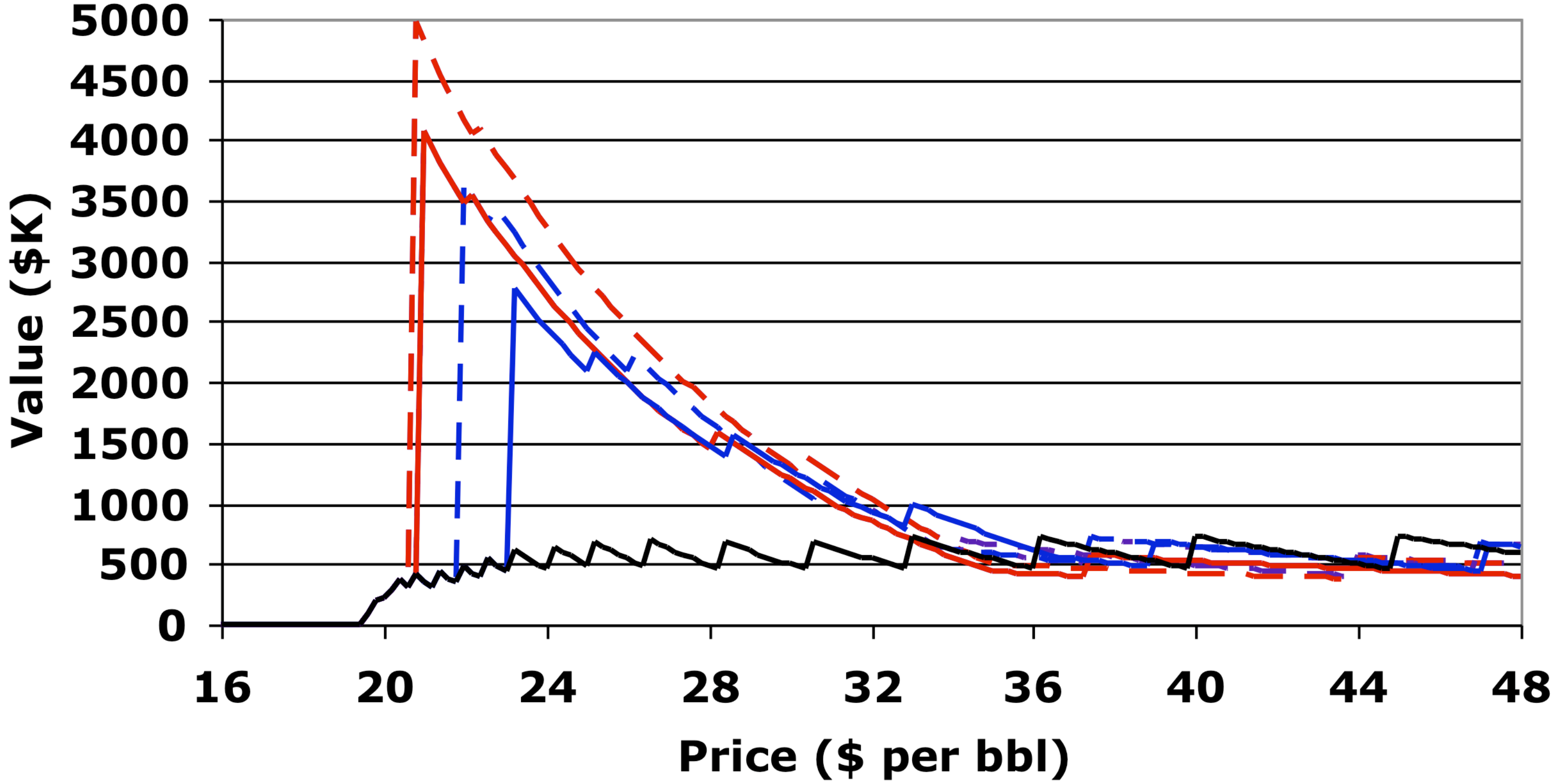
Determine, for each current price, optimal policy for,
and value of, prespecified intervention options

Determine value of contingent decision-making

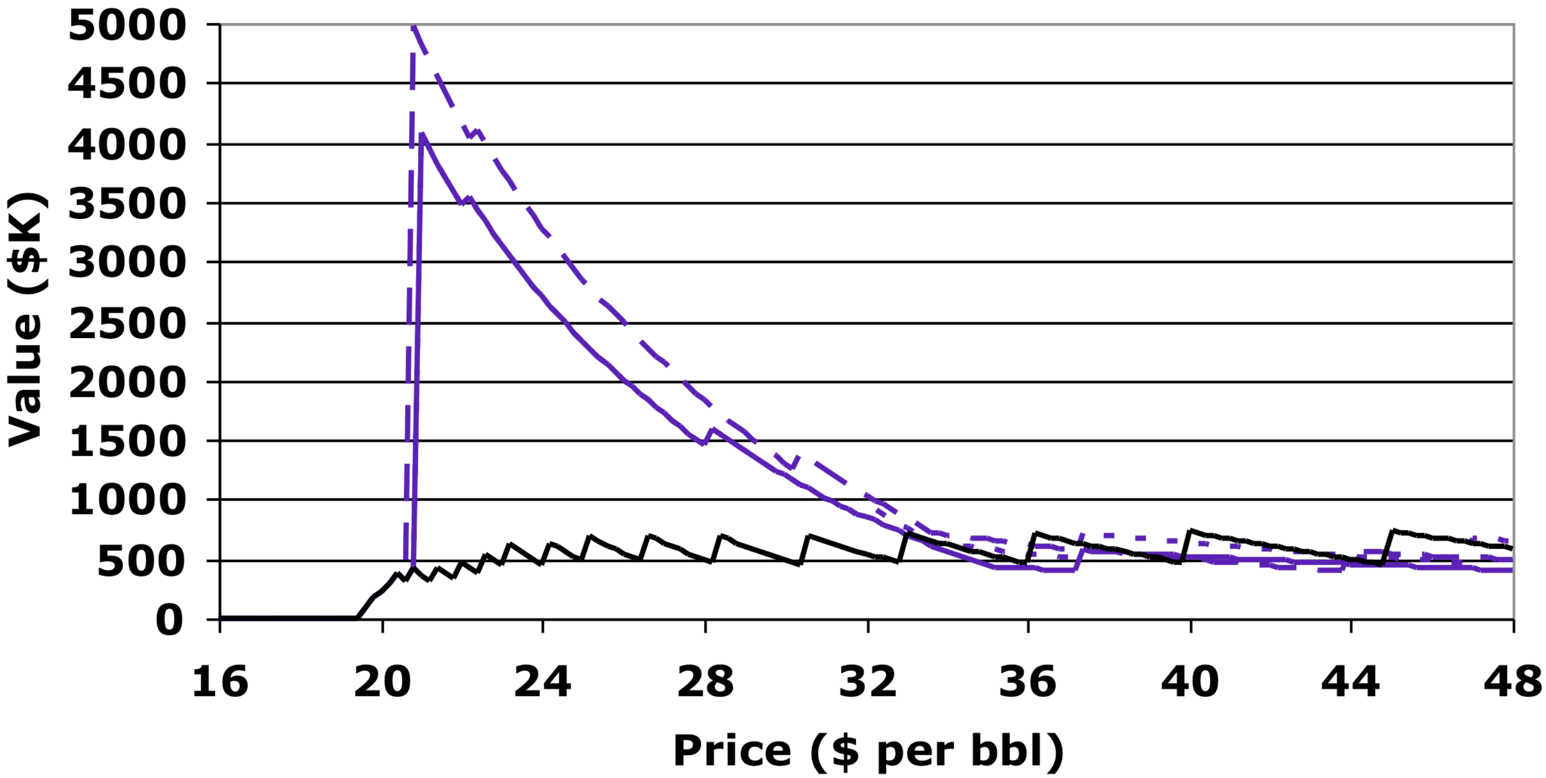
Determine value lost by following DCF policy

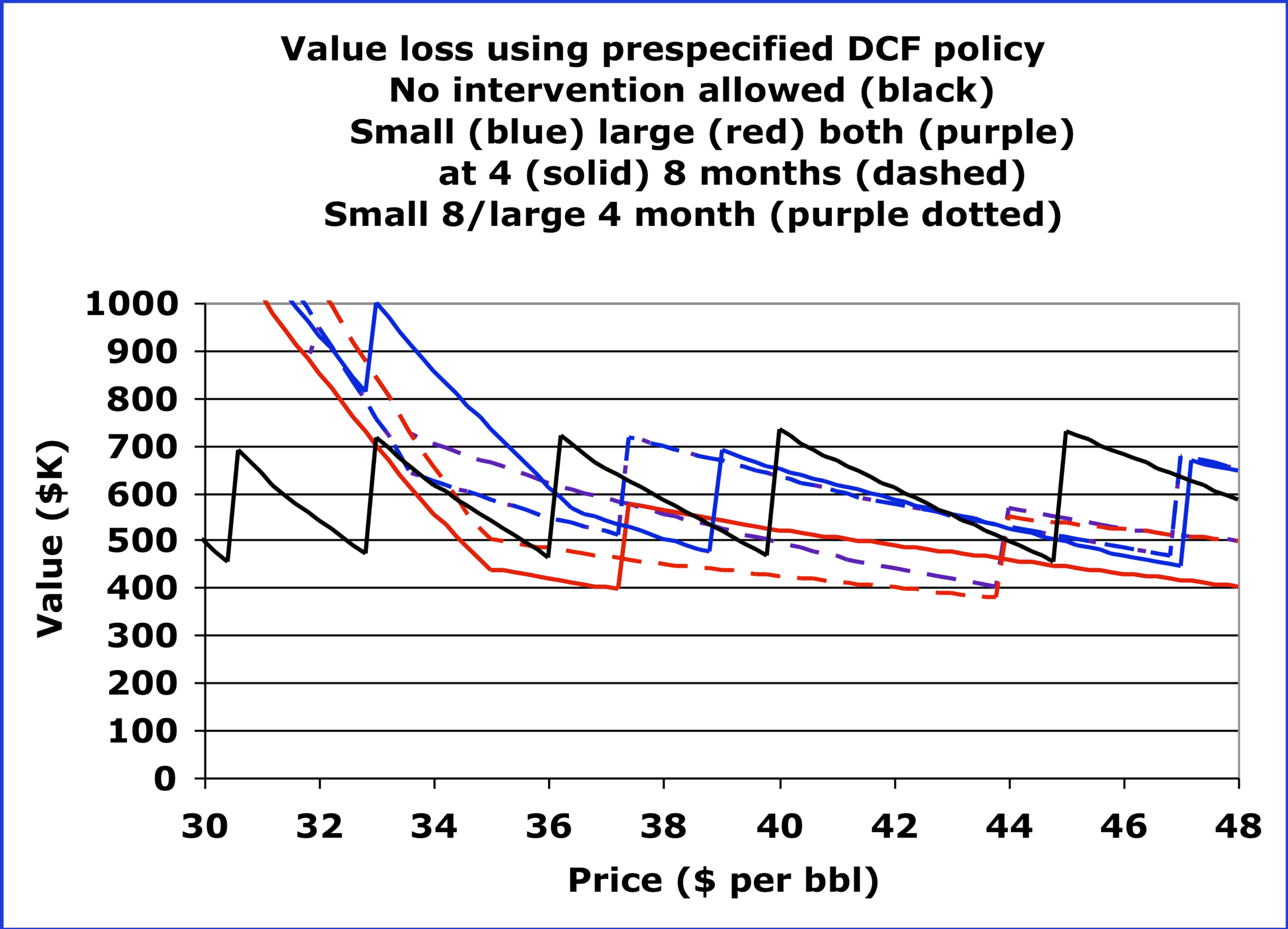

Value loss using DCF policy
No intervention allowed (black)
Small (blue) large (red) both (purple)
at 4 (solid) 8 or 4/8 months (dashed)
Contingent decision-making
Value ($K)
0
100
200
300
400
500
600
700
800
16
20
24
28
32
36
40
44
48
Price ($ per bbl)

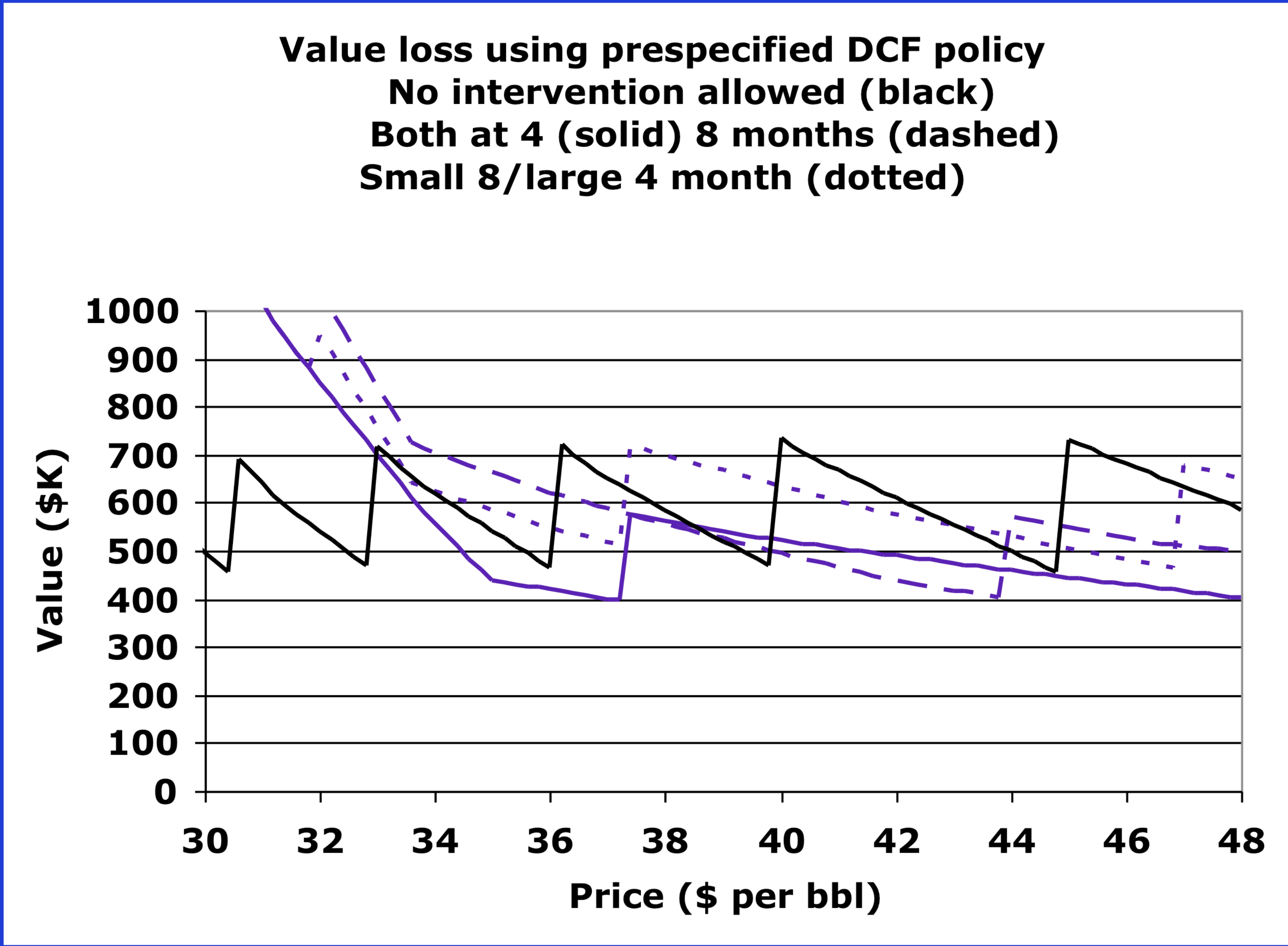
**Value loss using prespecified DCF policy**
**No intervention allowed (black)**
**Small (blue) large (red) both (purple)**
**at 4 (solid) 8 months (dashed)**
**Small 8/large 4 month (purple dotted)**



**Value loss using prespecified DCF policy**
**No intervention allowed (black)**
**Both at 4 (solid) 8 months (dashed)**
**Small 8/large 4 month (dotted)**




Value loss using prespecified DCF policy
No intervention allowed (black)
Small (blue) large (red) both (purple)
at 4 (solid) 8 months (dashed)
Small 8/large 4 month (purple dotted)
Value ($K)
1000
900
800
700
600
500
400
300
200
100
0
30
32
34
36
38
40
42
44
46
48
Price ($ per bbl)


Value loss using prespecified DCF policy
No intervention allowed (black)
Both at 4 (solid) 8 months (dashed)
Small 8/large 4 month (dotted)
1000
900
800
700
600
500
400
300
200
100
0
Value ($K)
30
32
34
36
38
40
42
44
46
48
Price ($ per bbl)

# Comments

Adding options to intervene greatly increases value loss
from using DCF policy recommendations,
except with prespecified decisions at high prices

Much greater effects at moderate prices
for prespecified decisions

Complex dependence on types of intervention allowed

# Future flexibility

How much value is added if decisions are made,
not unconditionally now,
but conditional on events up to the time
action is taken?

Examine a monthly decision on
whether to abandon or continue production

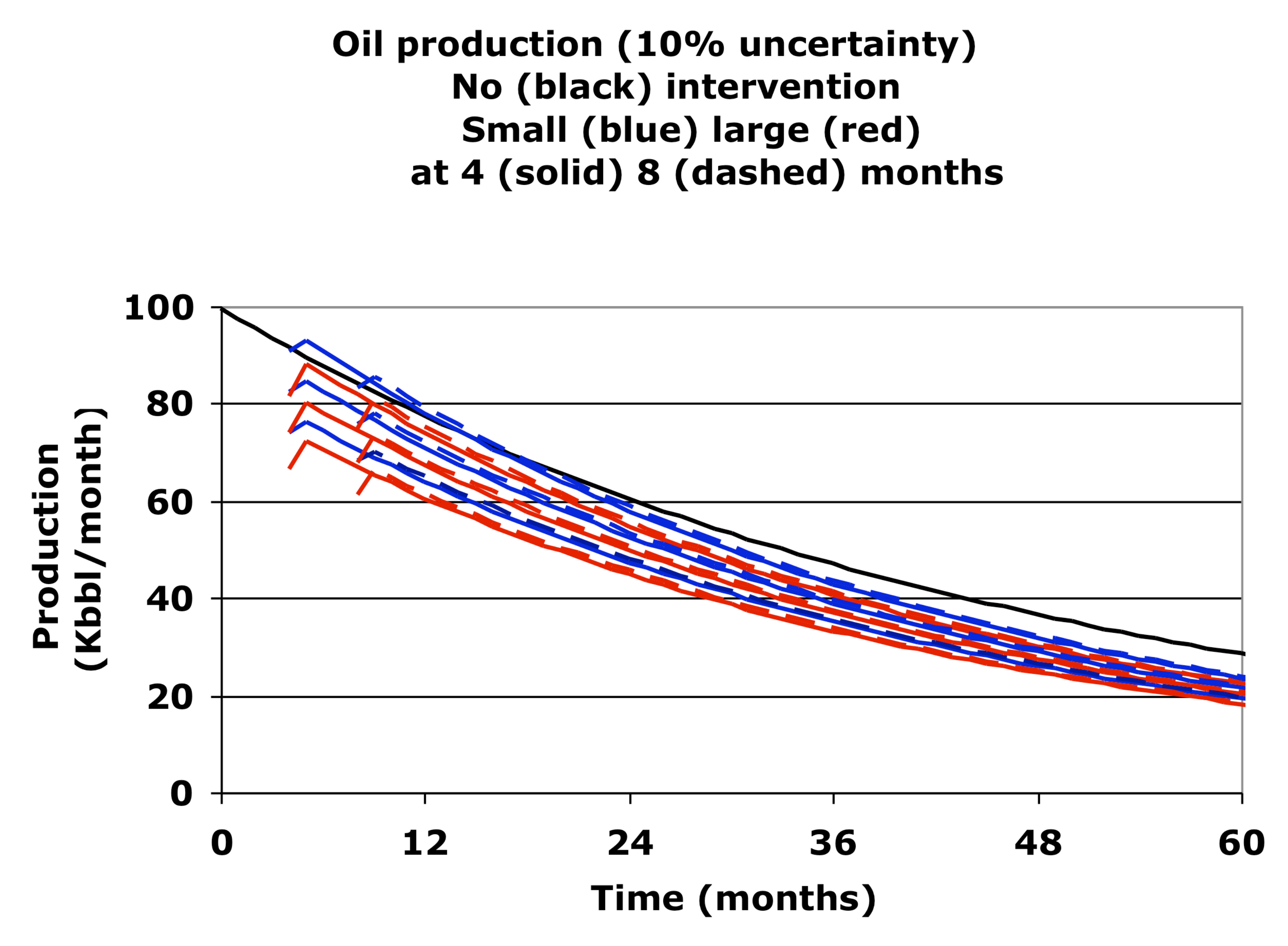
Next add in various combinations of flexibility in
intervention

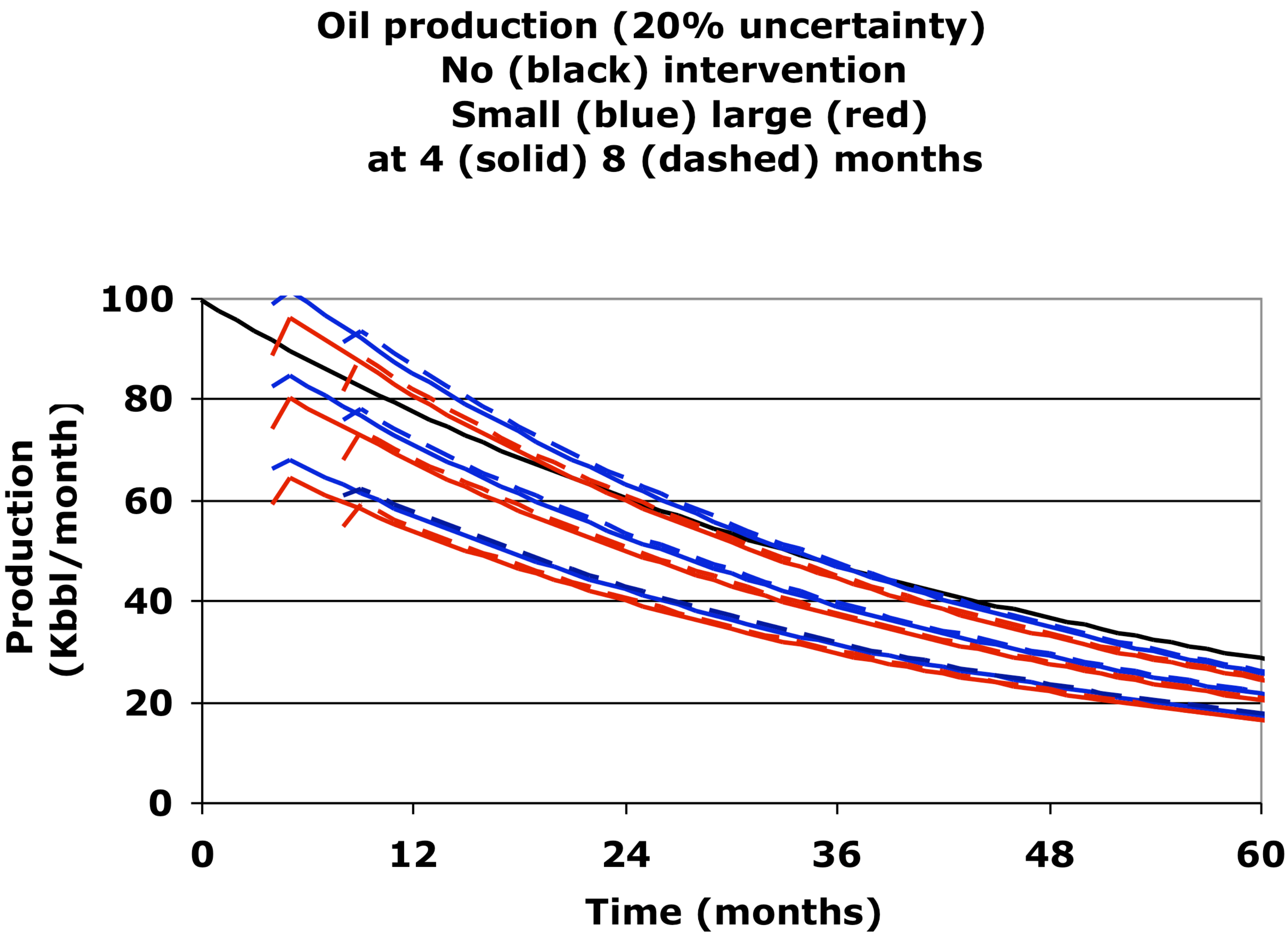
Finally examine the effect of uncertainty in production of
oil and/or water as a result of intervention

# Uncertainty in fluid amounts

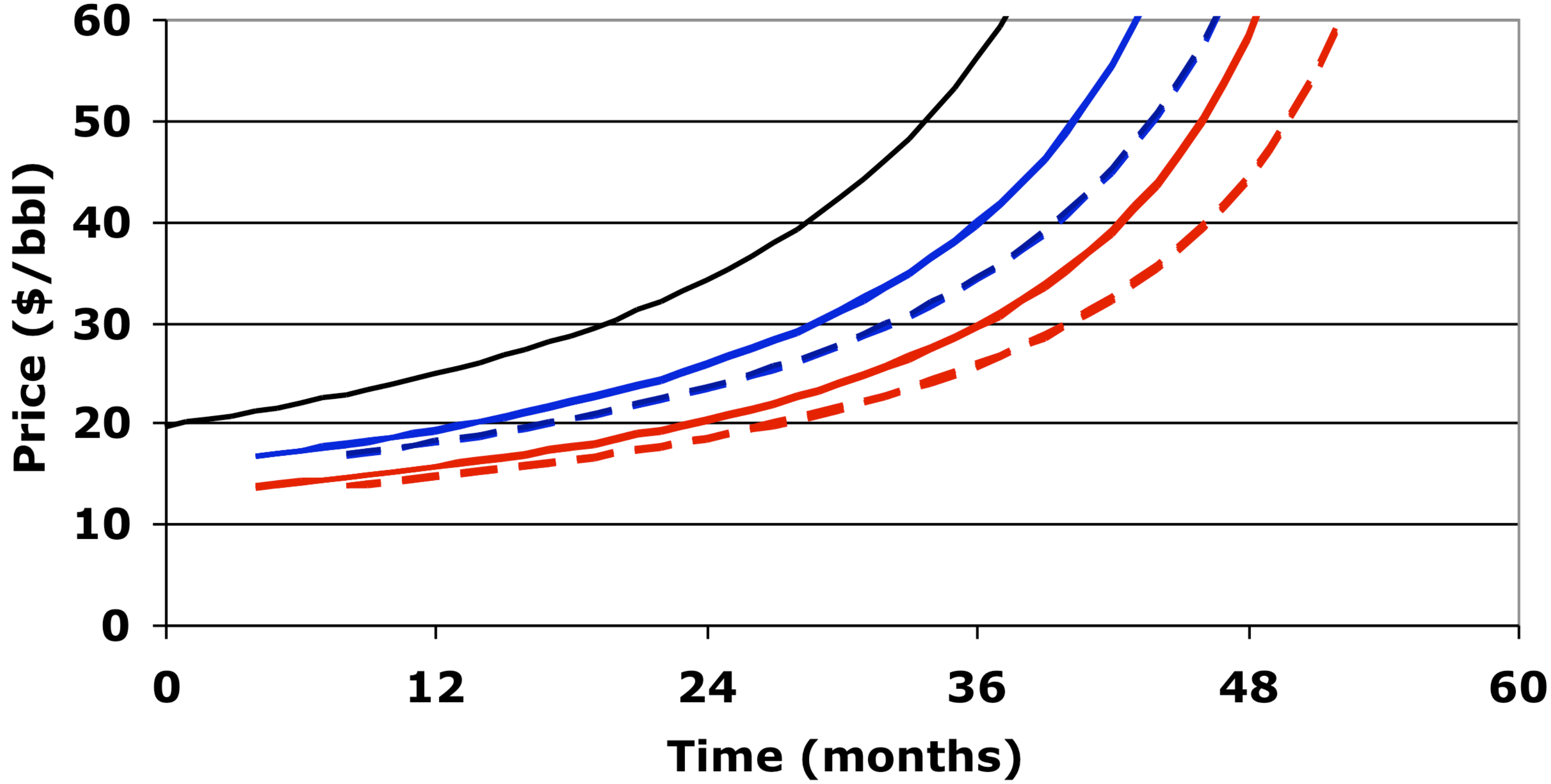
Consider three types and two levels of uncertainty
resulting from intervention:

10% and 20% uncertainty,
with same proportional profiles, in
oil and water (little uncertainty in unit cost)
water only (no uncertainty in production)
oil only (uncertainty in both)

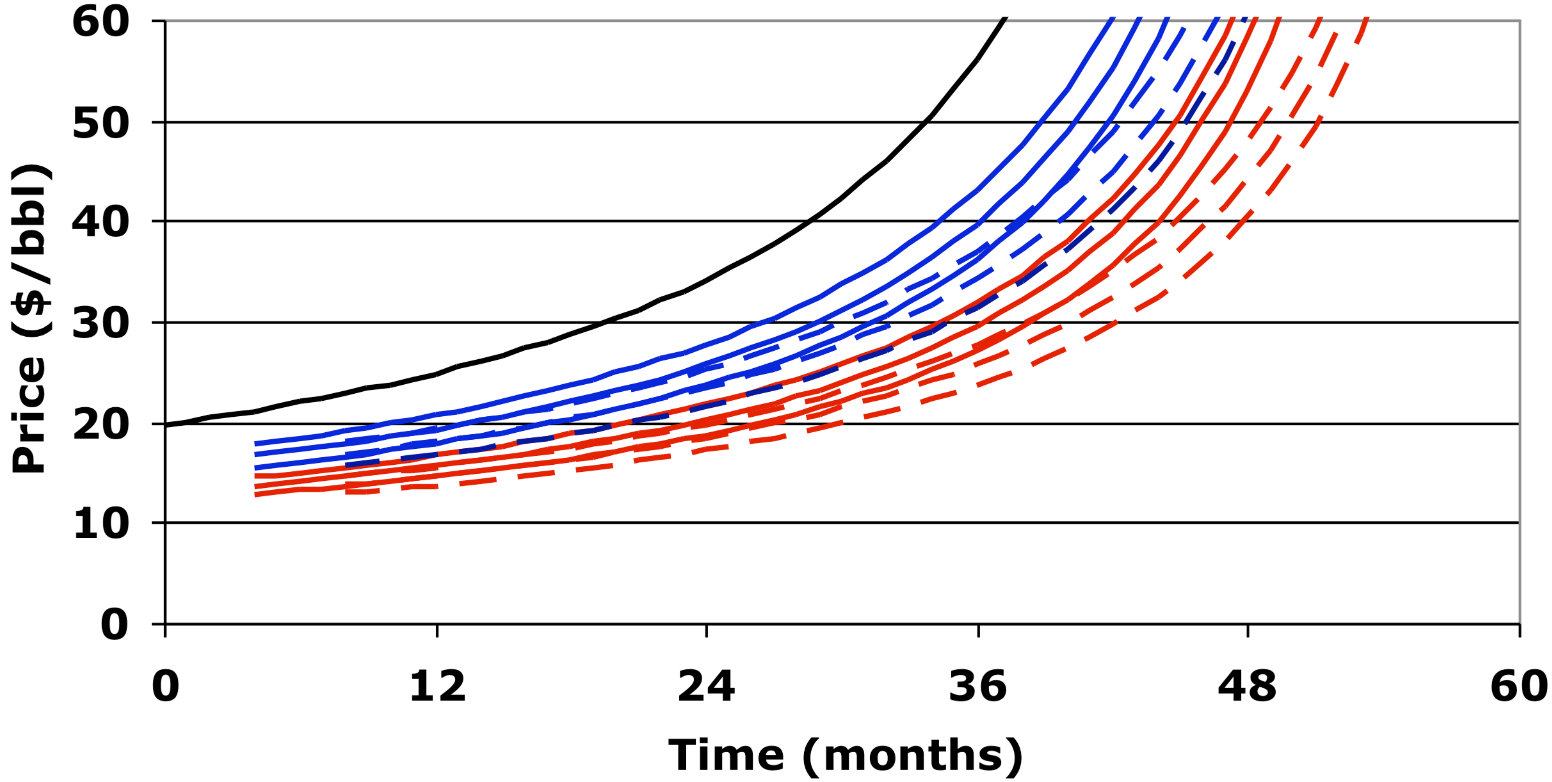

Oil production (10% uncertainty)
No (black) intervention
Small (blue) large (red)
at 4 (solid) 8 (dashed) months
100
80
60
40
20
0
Production
(Kbbl/month)
0
12
24
36
48
60
Time (months)


Oil production (20% uncertainty)
No (black) intervention
Small (blue) large (red)
at 4 (solid) 8 (dashed) months
100
80
60
40
20
0
Production (Kbbl/month)
0
12
24
36
48
60
Time (months)

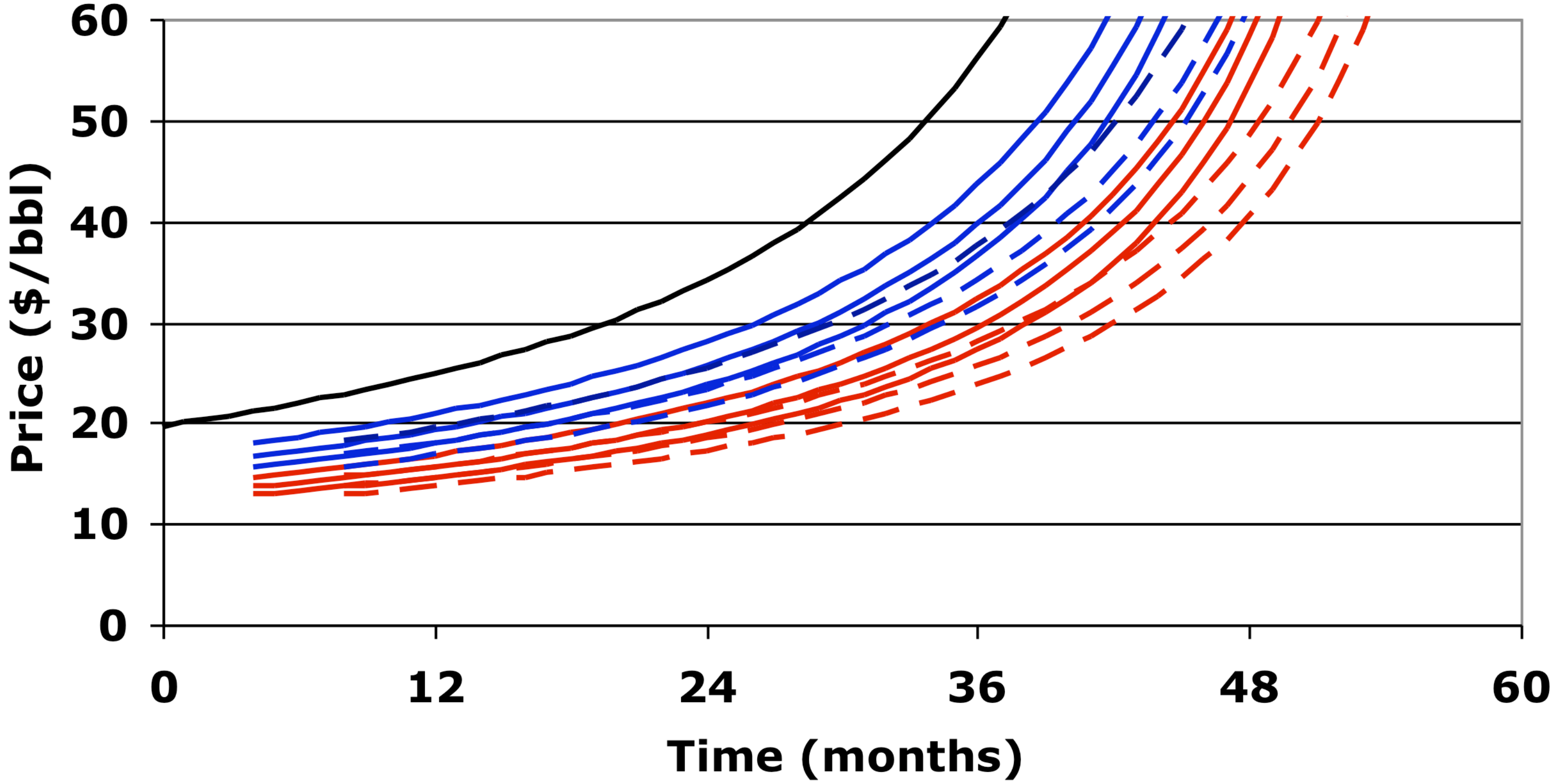
## Unit operating cost (20% fluid uncertainty)
## No (black) intervention
## Small (blue) large (red)
## at 4 (solid) 8 (dashed) months



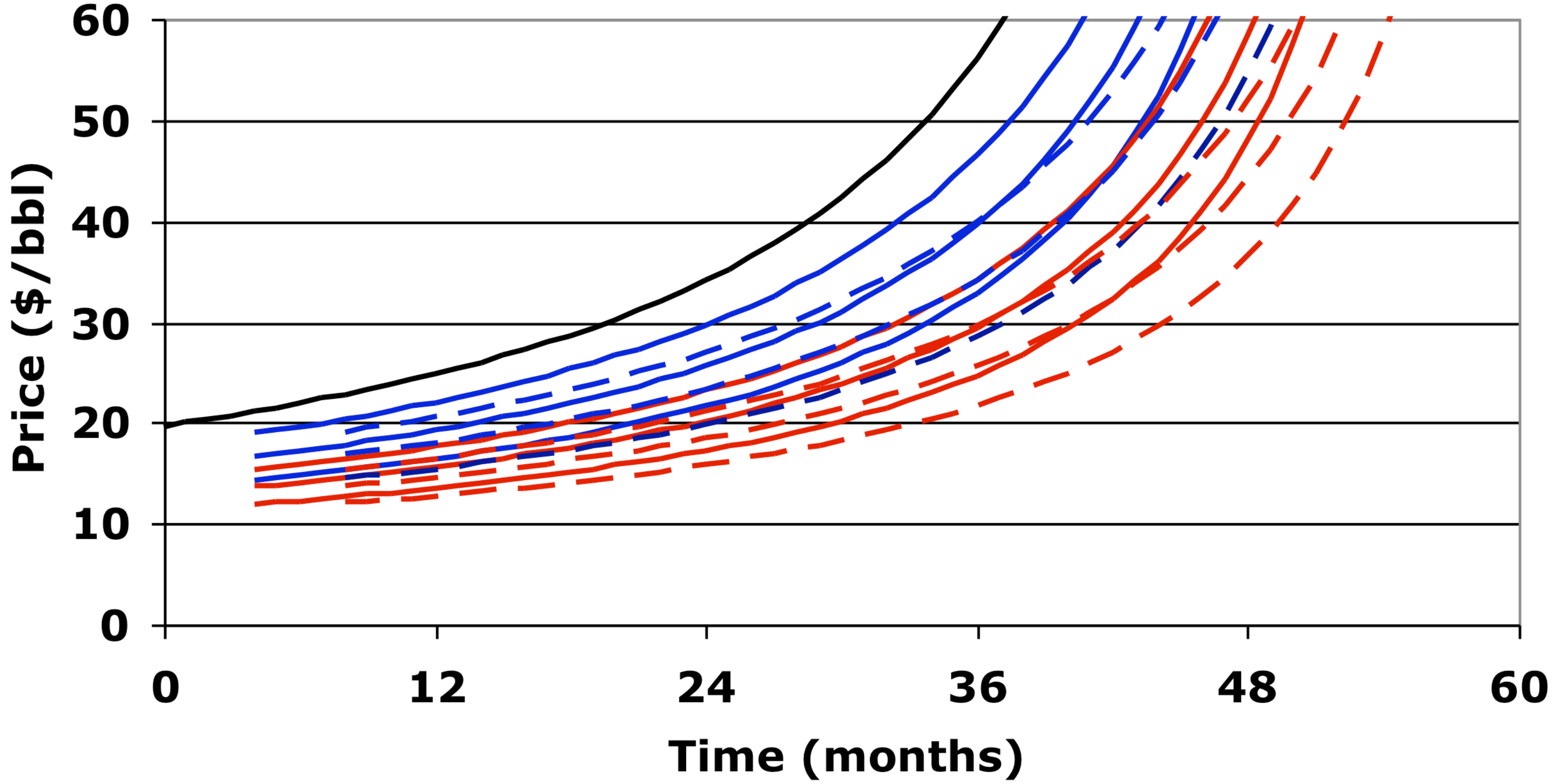
**Unit operating cost (10% water uncertainty)**
**No (black) intervention**
**Small (blue) large (red)**
**at 4 (solid) 8 (dashed) months**



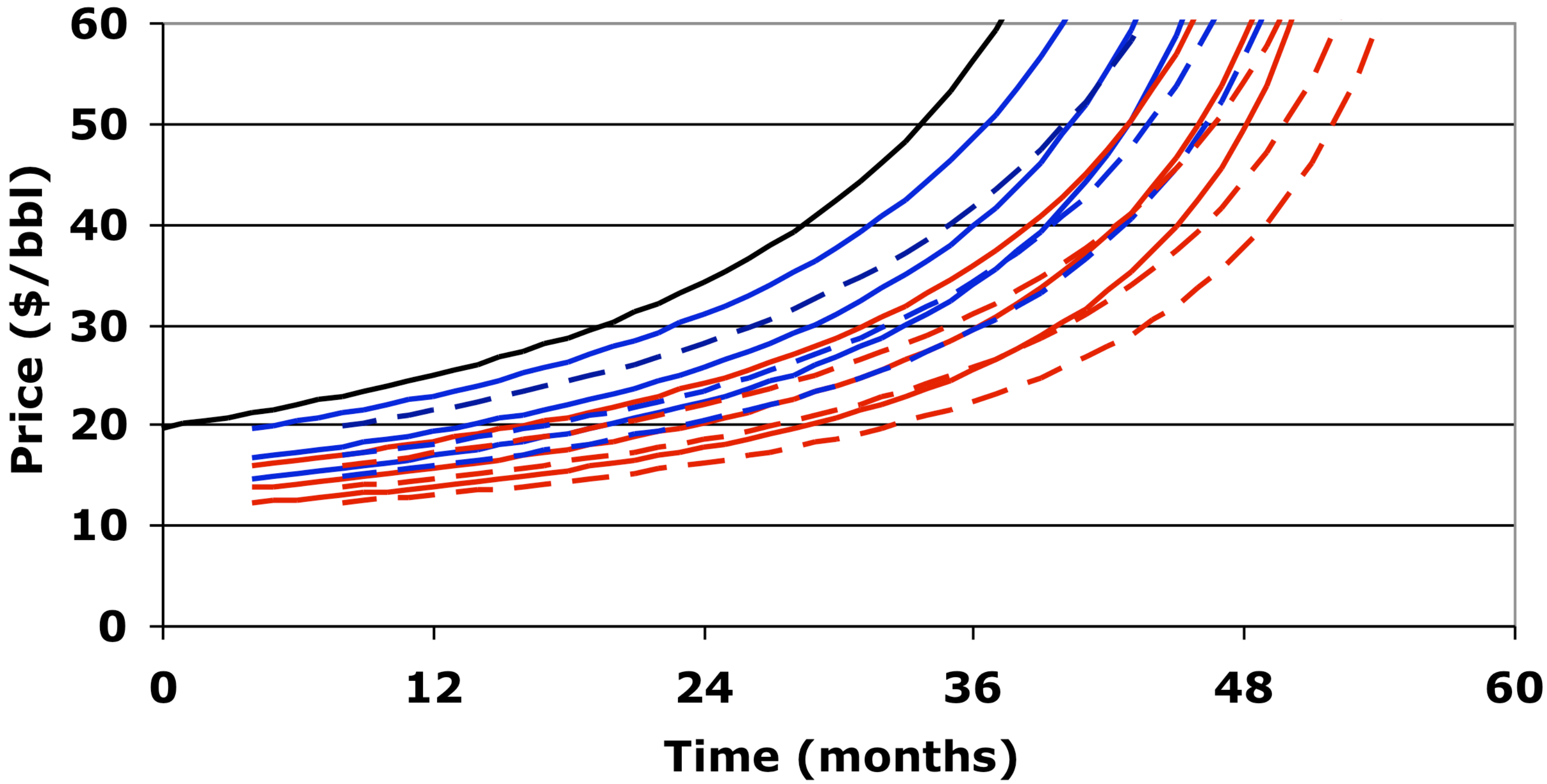
## Unit operating cost (10% oil uncertainty)
## No (black) intervention
## Small (blue) large (red)
## at 4 (solid) 8 (dashed) months



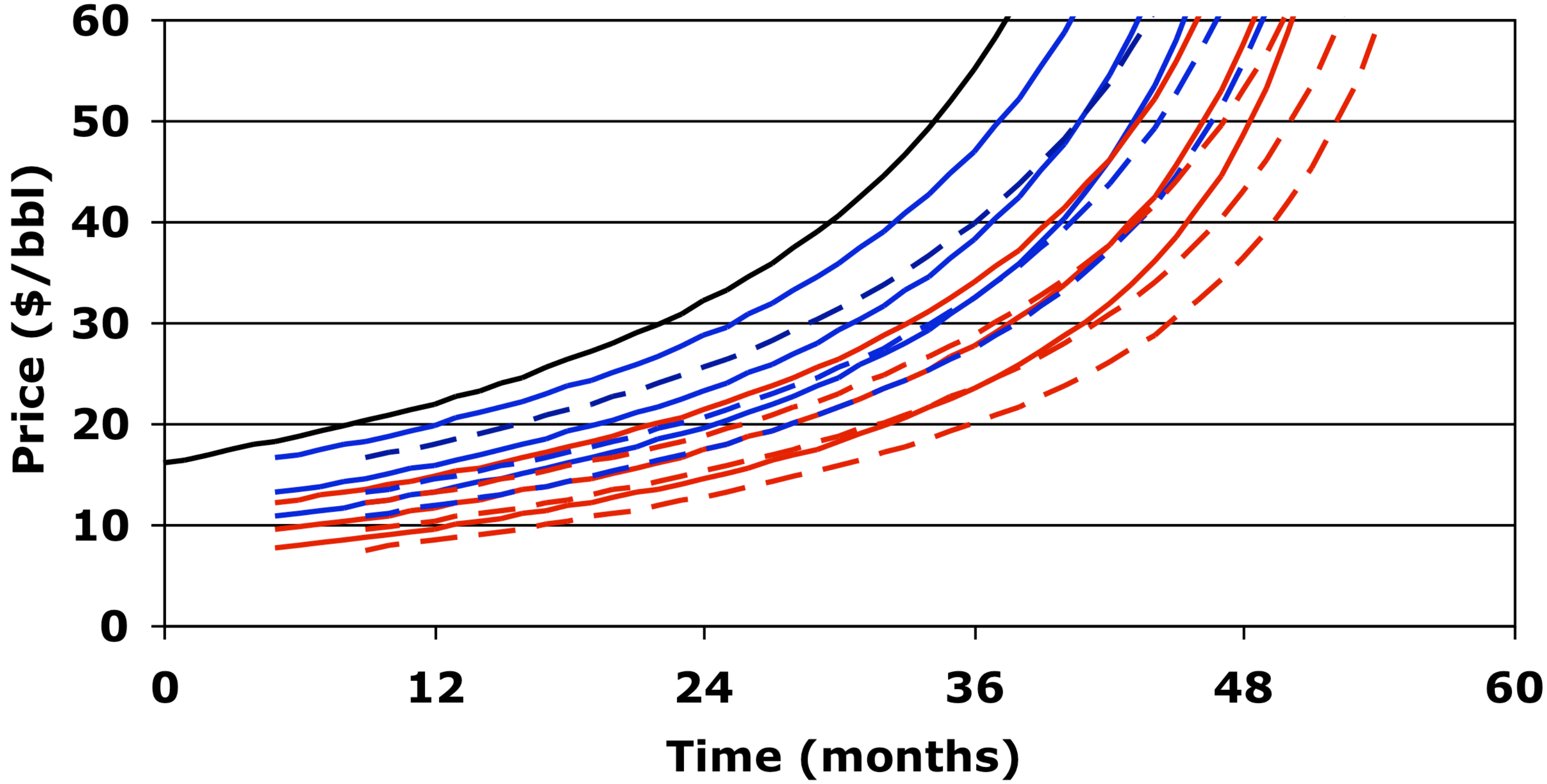
## Unit operating cost (20% water uncertainty)
## No (black) intervention
## Small (blue) large (red)
## at 4 (solid) 8 (dashed) months

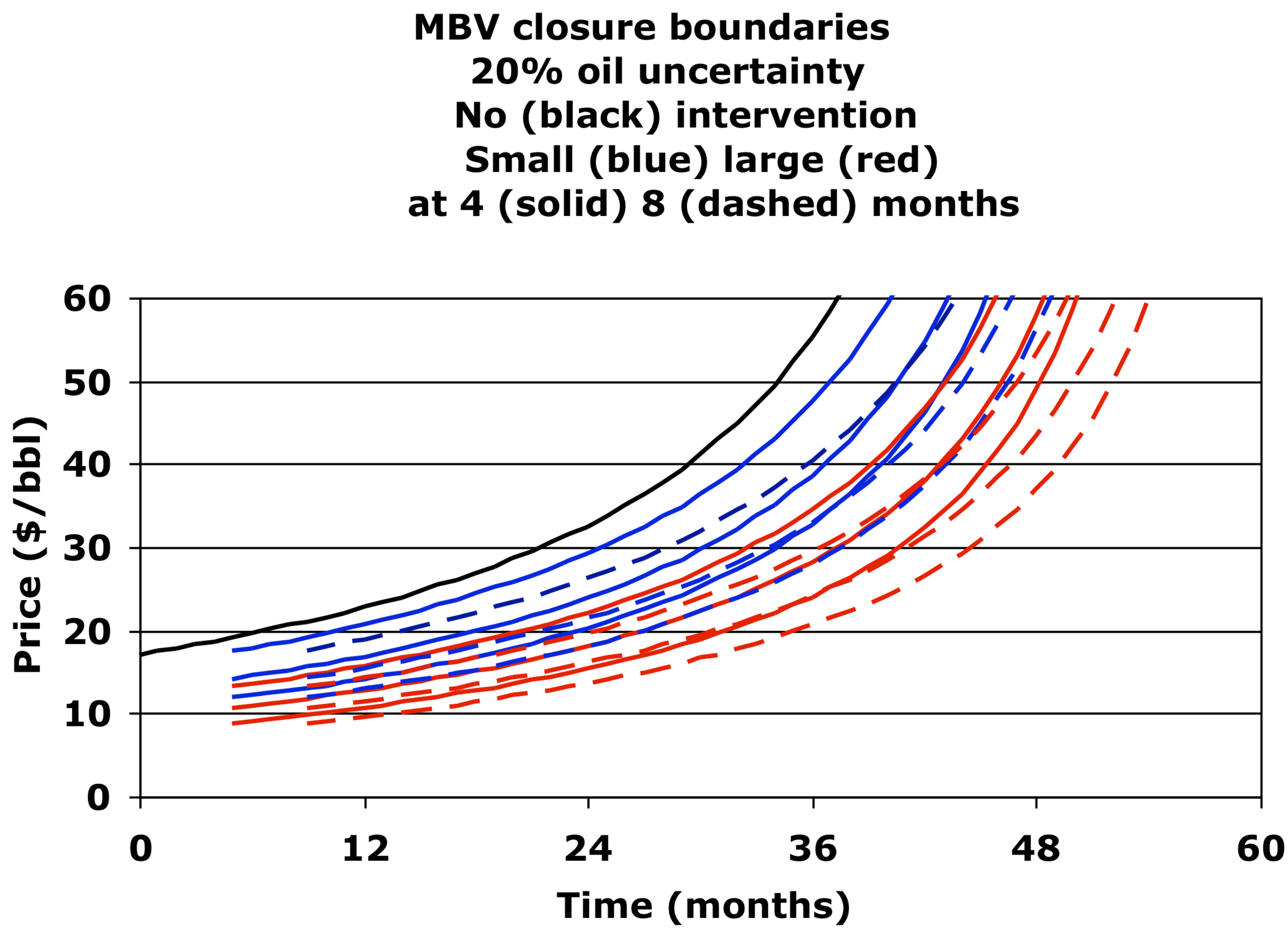


**Unit operating cost (20% oil uncertainty)**
**No (black) intervention**
**Small (blue) large (red)**
**at 4 (solid) 8 (dashed) months**



**DCF closure boundaries**
**20% oil uncertainty**
**No (black) intervention**
**Small (blue) large (red)**
**at 4 (solid) 8 (dashed) months**




MBV closure boundaries
20% oil uncertainty
No (black) intervention
Small (blue) large (red)
at 4 (solid) 8 (dashed) months
Price ($/bbl)
0
10
20
30
40
50
60
0
12
24
36
48
60
Time (months)

# Optimal DCF choices at 4 and 8 months All interventions available

| Unc | Act | Bound | Act | Bound | Act | Bound | Act | Bound | Act |
|---|---|---|---|---|---|---|---|---|---|
| 4 months | | | | | | | | | |
| none | C | 17.4 | N | | N | | N | | N |
| 10 f | C | 17.4 | N | | N | | N | | N |
| 20 f | C | 17.4 | N | | N | | N | | N |
| 10 w | C | 17.4 | N | | N | | N | | N |
| 20 w | C | 17.3 | N | | N | | N | | N |
| 10 o | C | 17.4 | N | | N | | N | | N |
| 20 o | C | 17.3 | N | | N | | N | | N |
| 8 months | | | | | | | | | |
| none | C | 19.8 | N | 22.0 | L | | L | 61.4 | S |
| 10 f | C | 19.8 | N | 22.0 | L | | L | 61.5 | S |
| 20 f | C | 19.8 | N | 22.0 | L | | L | 61.5 | S |
| 10 w | C | 19.8 | N | 21.9 | S | 22.0 | L | 60.9 | S |
| 20 w | C | 19.8 | N | 21.5 | S | 23.0 | L | 59.1 | S |
| 10 o | C | 19.8 | N | 21.9 | S | 22.0 | L | 60.9 | S |
| 20 o | C | 19.8 | N | 21.4 | S | 23.1 | L | 59.1 | S |

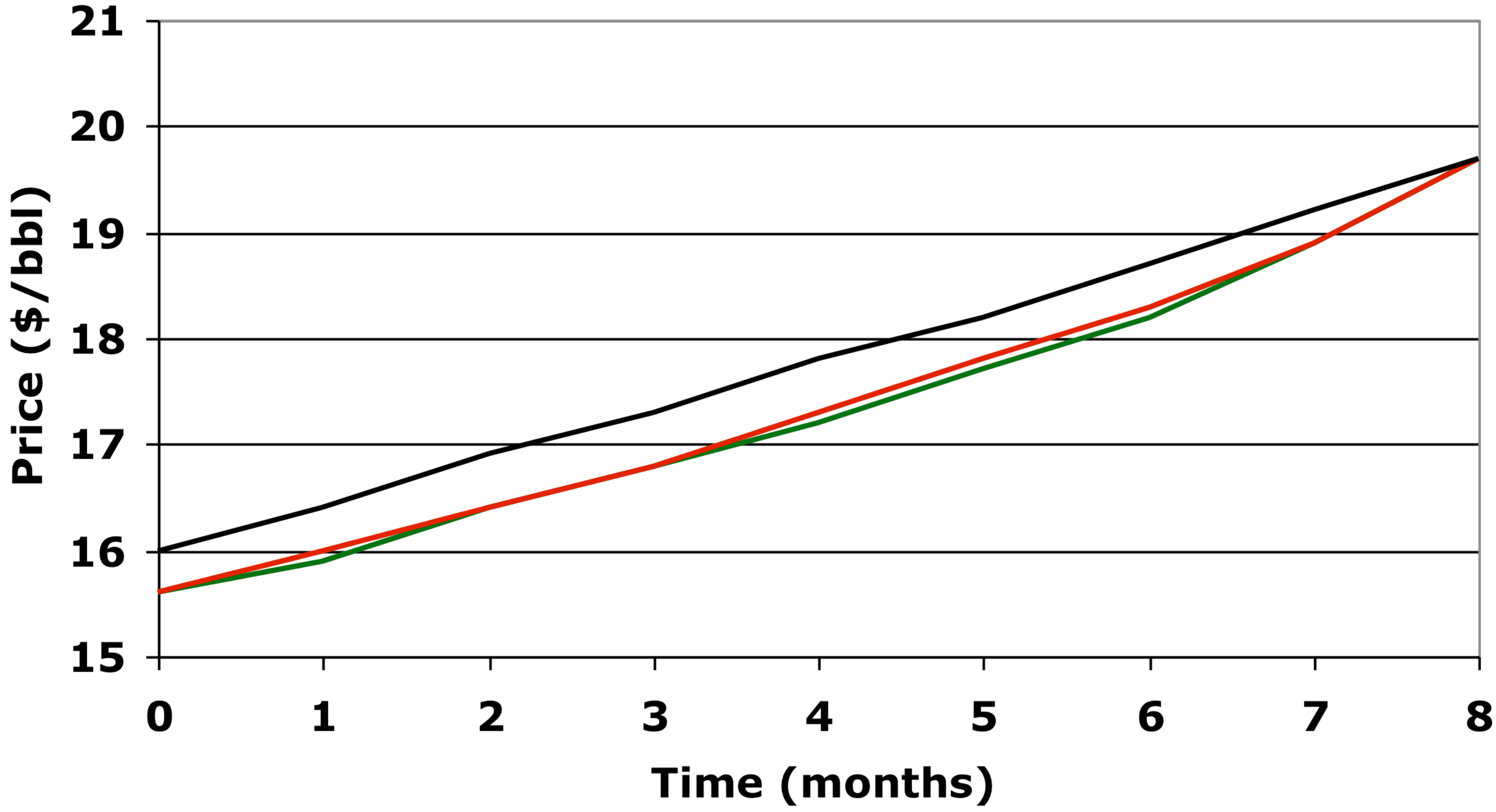
Unc Type of uncertainty (10/20%, fluids/water/oil)

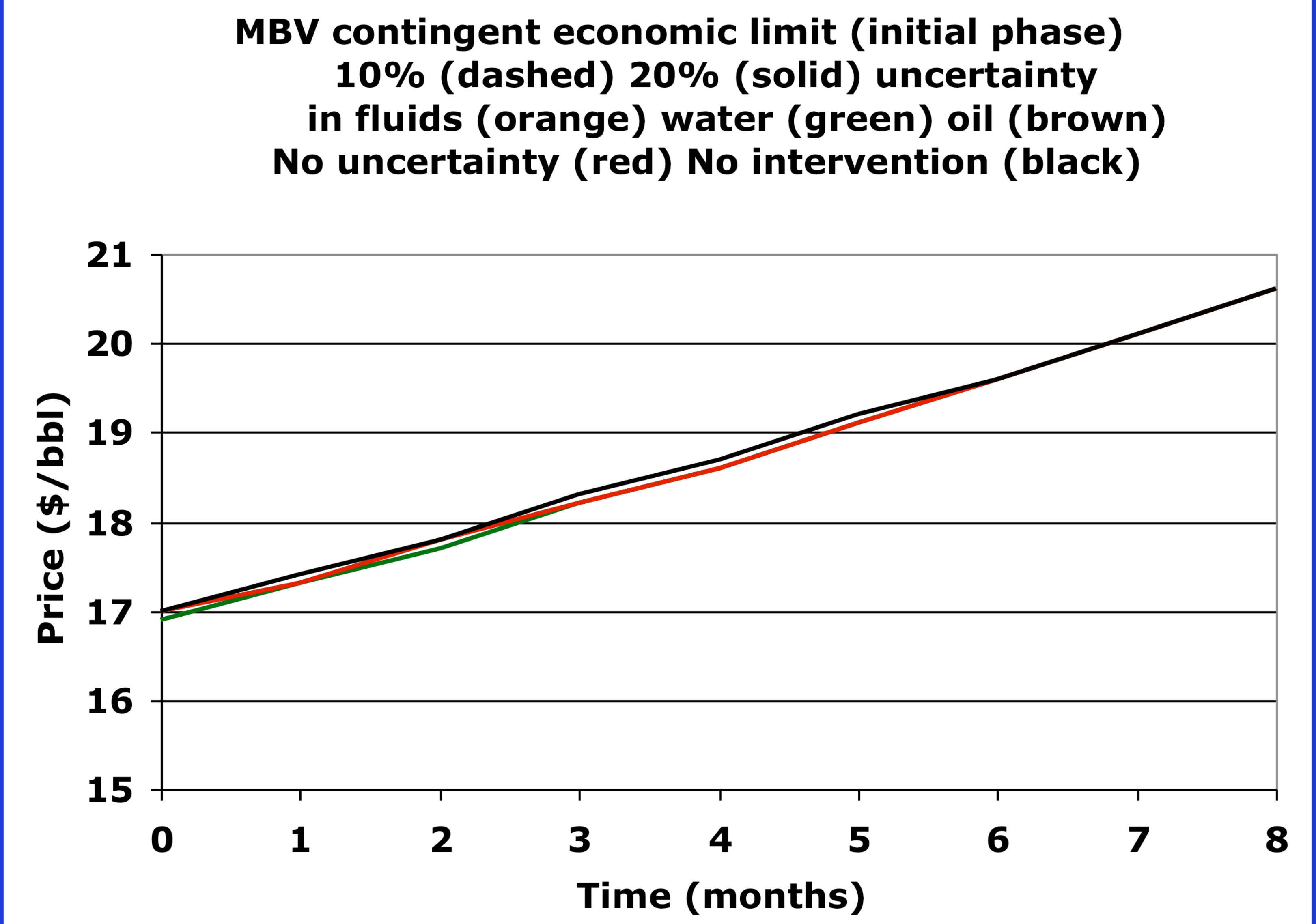
# Optimal MBV choices at 4 and 8 months All interventions available

| Avail Int | Act | Bound | Act | Bound | Act | Bound | Act | Bound | Act |
|---|---|---|---|---|---|---|---|---|---|
| 4 months | | | | | | | | | |
| none | C | 18.7 | N | | N | | N | | N |
| 10 f | C | 18.7 | N | | N | | N | | N |
| 20 f | C | 18.7 | N | | N | | N | | N |
| 10 w | C | 18.7 | N | | N | | N | | N |
| 20 w | C | 18.7 | N | | N | | N | | N |
| 10 o | C | 18.7 | N | | N | | N | | N |
| 20 o | C | 18.7 | N | | N | | N | | N |
| 8 months | | | | | | | | | |
| none | C | 20.7 | N | 26.8 | S | | S | | S |
| 10 f | C | 20.7 | N | 26.8 | S | | S | | S |
| 20 f | C | 20.7 | N | 26.8 | S | | S | | S |
| 10 w | C | 20.7 | N | 26.5 | S | | S | | S |
| 20 w | C | 20.7 | N | 25.9 | S | | S | | S |
| 10 o | C | 20.7 | N | 26.5 | S | | S | | S |
| 20 o | C | 20.7 | N | 25.8 | S | | S | | S |

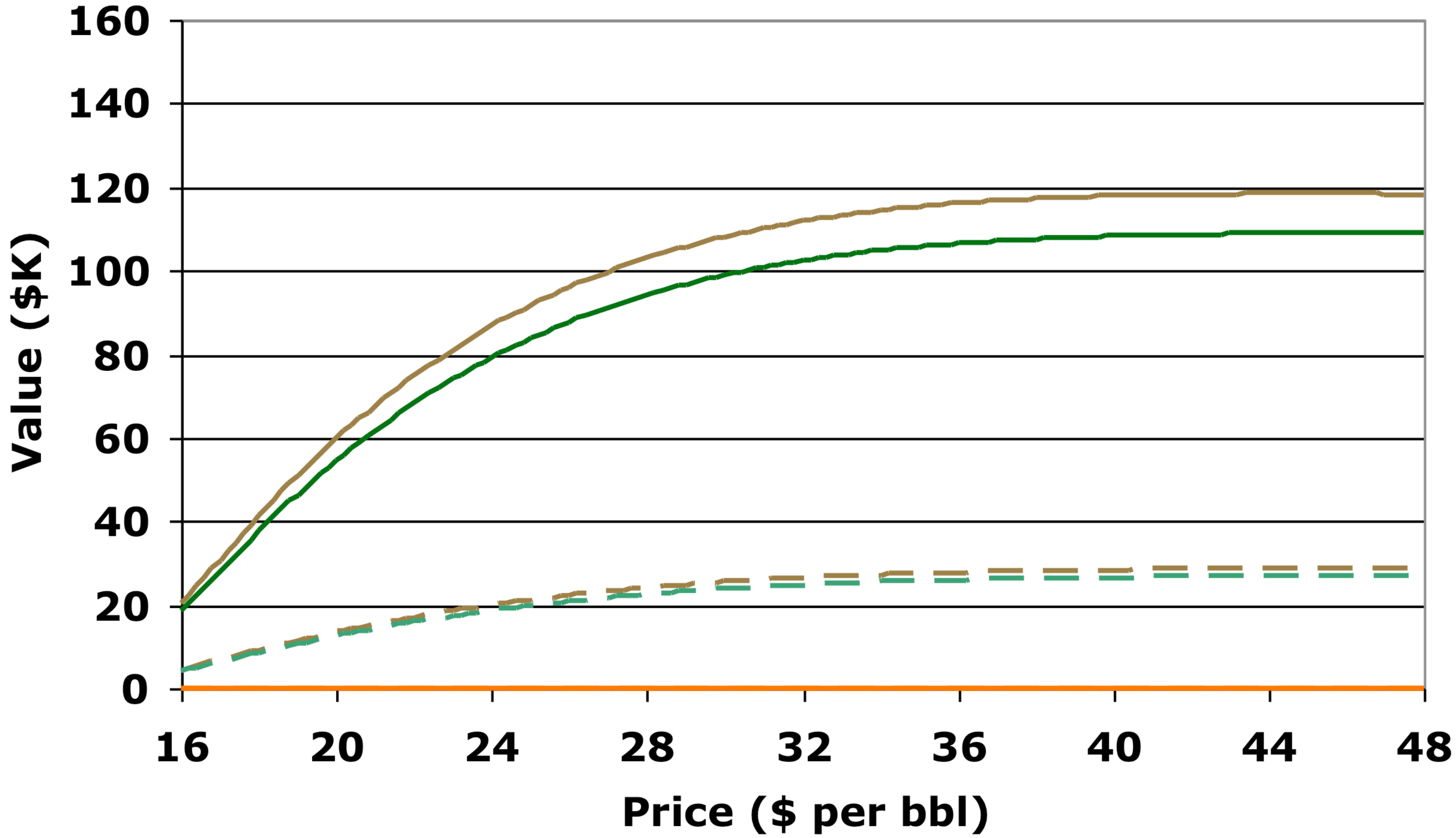
Unc Type of uncertainty (10/20%, fluids/water/oil)

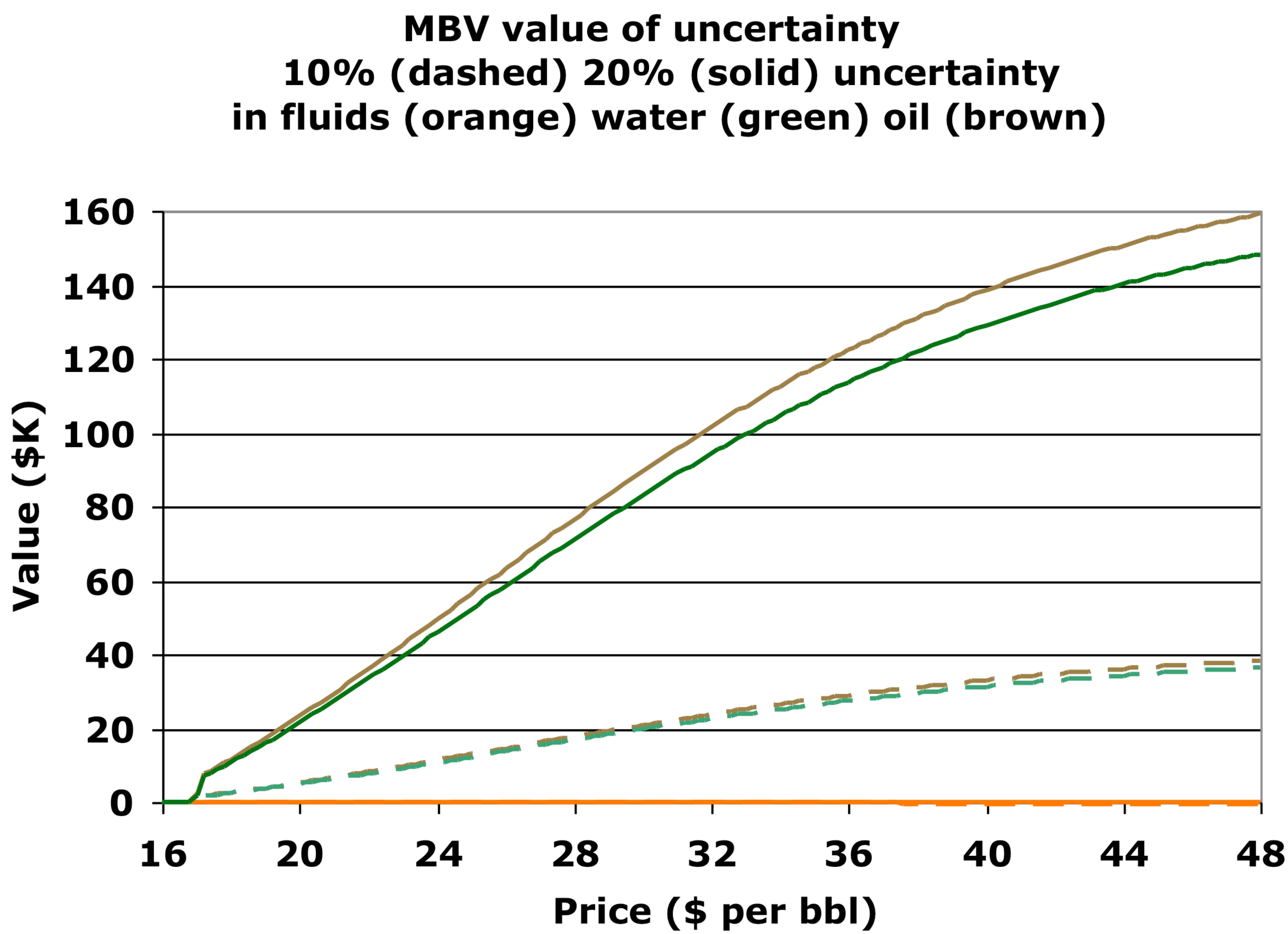
DCF contingent economic limit (initial phase)
10% (dashed) 20% (solid) uncertainty
in fluids (orange) water (green) oil (brown)
No uncertainty (red) No intervention (black)

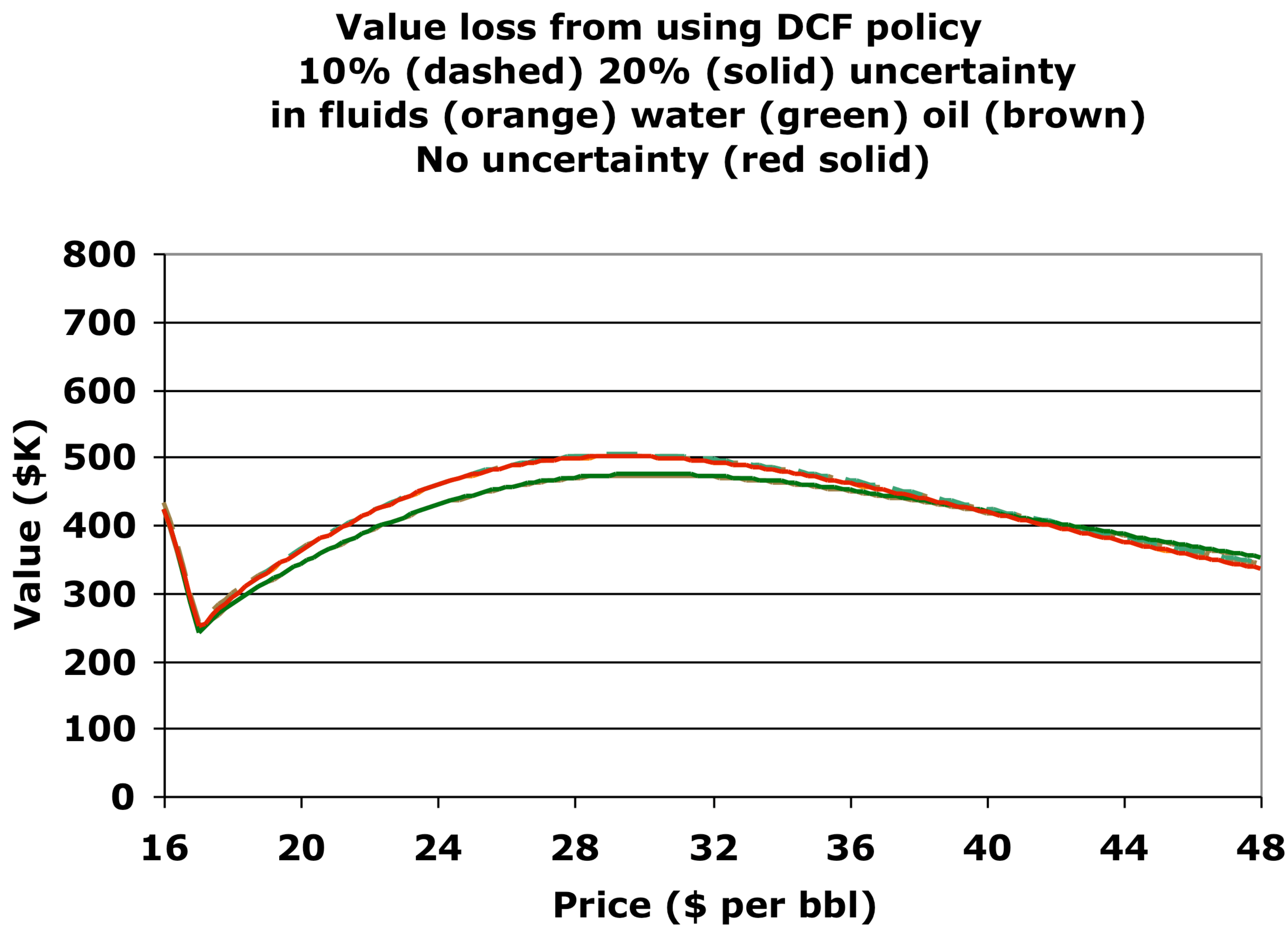



MBV contingent economic limit (initial phase)
10% (dashed) 20% (solid) uncertainty
in fluids (orange) water (green) oil (brown)
No uncertainty (red) No intervention (black)
Price ($/bbl)
21
20
19
18
17
16
15
0
1
2
3
4
5
6
7
8
Time (months)

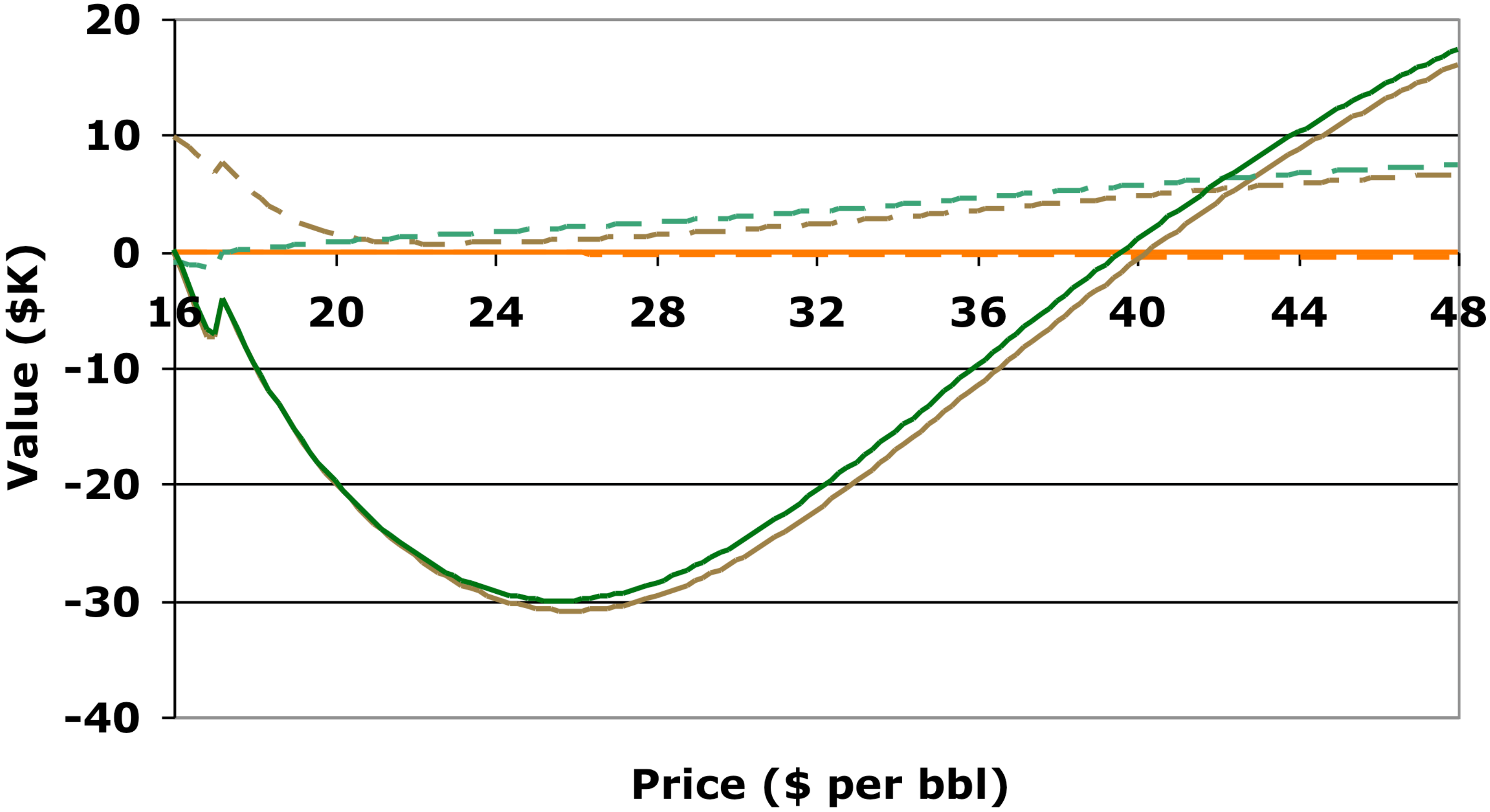
## DCF value of uncertainty
## 10% (dashed) 20% (solid) uncertainty
## in fluids (orange) water (green) oil (brown)




MBV value of uncertainty
10% (dashed) 20% (solid) uncertainty
in fluids (orange) water (green) oil (brown)
Value ($K)
160
140
120
100
80
60
40
20
0
16
20
24
28
32
36
40
44
48
Price ($ per bbl)


Value loss from using DCF policy
10% (dashed) 20% (solid) uncertainty
in fluids (orange) water (green) oil (brown)
No uncertainty (red solid)
800
700
600
500
400
300
200
100
0
Value ($K)
16
20
24
28
32
36
40
44
48
Price ($ per bbl)

# Incremental value loss from using DCF policy due to uncertainty 10% (dashed) 20% (solid) uncertainty in fluids (orange) water (green) oil (brown)



# Comments

Uncertainty in production without uncertainty in unit cost
has no effect on pre-intervention management/value

Uncertainty in unit cost
increases value and lowers intervention threshold

# Remarks

Contingent decision-making important at end of asset life

Valuation matters
  Using the DCF "one size fits all" approach
    to valuation of uncertainty can destroy value

A more precise approach is possible,
  but requires more work and a change in process

# Outline

A basic set of questions

Some examples

Summary of some insights from financial markets

The Banff taxonomy of valuation methods and its uses
- Evolution of valuation in industry
- Developments in financial markets
- Where industry might go

An example analysed: Managing a mature field

Strategy formation and asset valuation

Organisational issues and management of change

Some dead ends

Some concluding remarks

# Strategy and valuation

## Strategic positioning and sources of value

"When an industry settles into long-term competitive equilibrium, all its assets are expected to return their opportunity cost of capital, no more, no less. A positive NPV is believable only if it comes from a special advantage."

**Approach to valuation should:**

Force reversion to equilibrium unless overridden
Focus on the different sources of advantage
Determine effects of sequential decision-making on creating advantage

## Strategy and planning: Imagination vs. prediction

Planning involves imagining:

What might happen

How one might respond

Analysis, including valuation, methods should

encourage consideration

of alternative futures

to tease out, prepare for responses

# Organisational issues in changing valuation methods

Knowledge imbedded
In current processes

Power
Relationships,
culture

Professional
Identity,
language

Distributed/
partial information

Behavioural
(decision-making biases)

Agency
(imperfectly aligned incentives)

## Distributed knowledge
## Language

Asset decisions led/made by senior management

Involve people throughout organisation:
Must be consistent and controlled

New methods require development of
new intuition, language, processes

Change requires major human and organisational
capital investments

# Power

Valuation often mediates power relationships

Used in performance measurement

Control of model (having others provide inputs) is a key source of power

Changes will be resisted if there are “losers”

# Basis for comparison of valuation methods

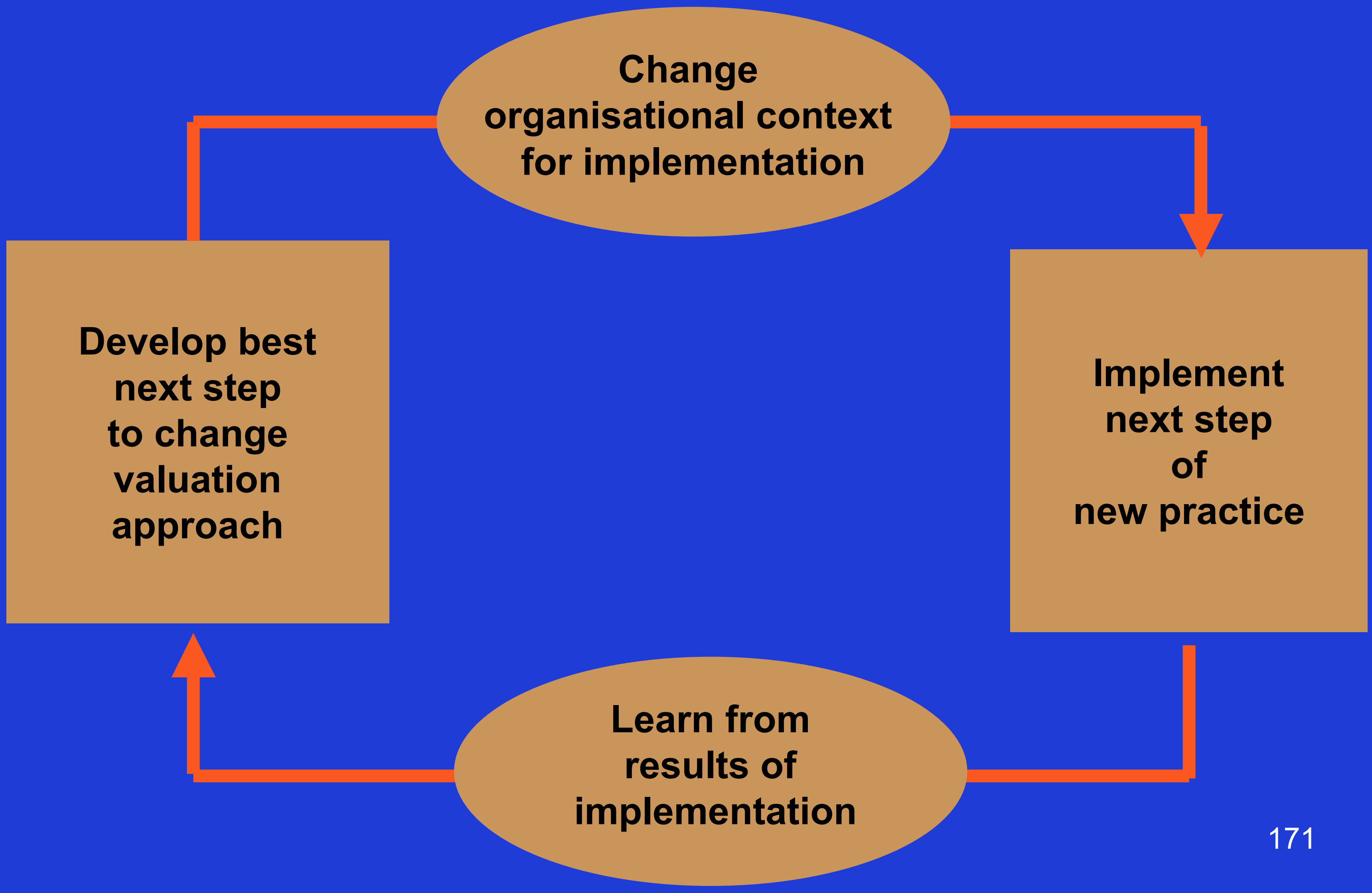
Strategy considerations

- Encourage thinking about range of outcomes
- Focus on source of value, creation of advantage
- Sequential decisions

Organisational considerations

- Cost of change from what is currently being done
- Changes in language, intuition, processes, power
- Maintain consistency, control, understanding, communication

# The process of change



# Criteria for steps

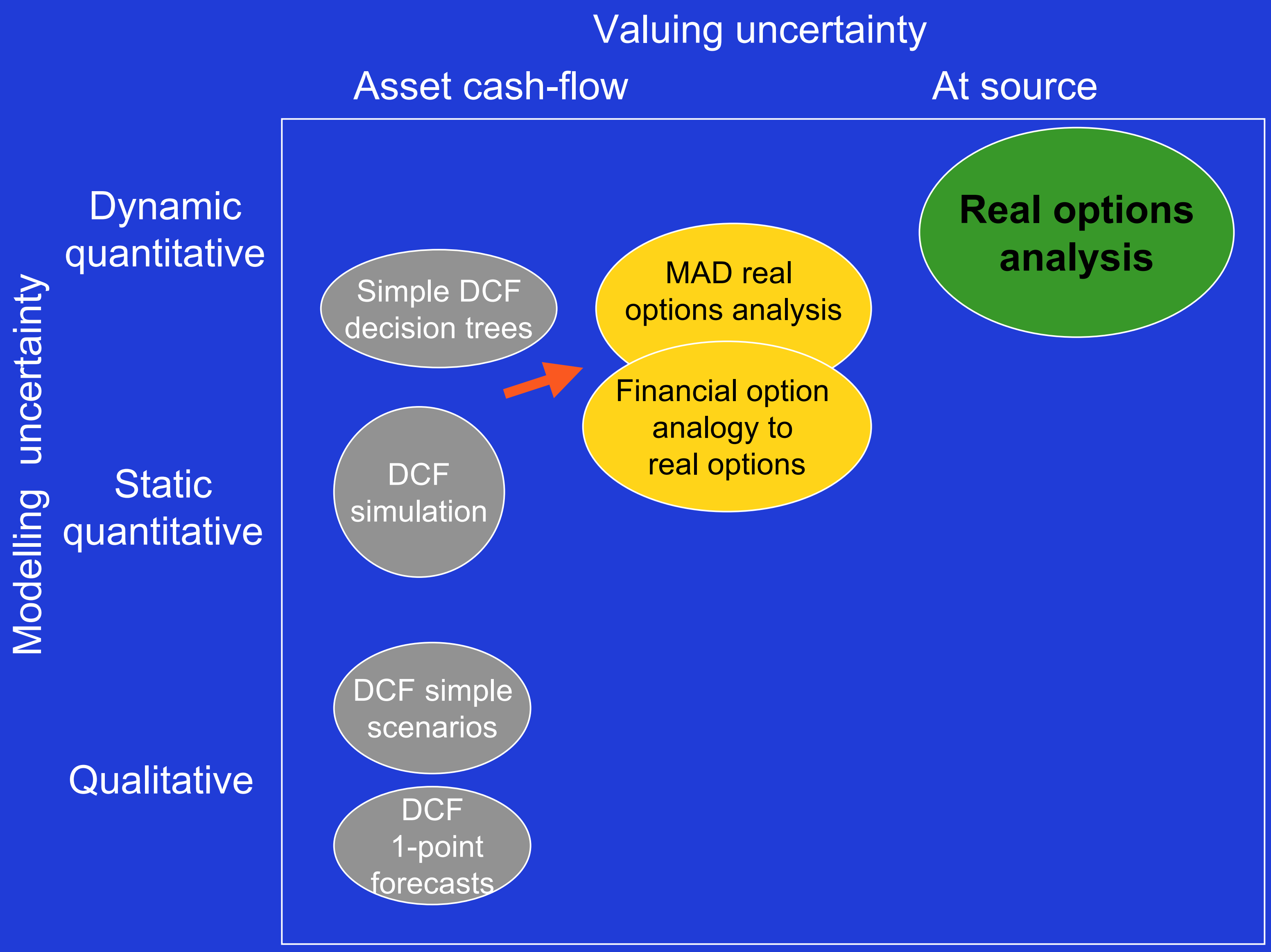
Big enough to be worth taking

Small enough to be done at as little cost as possible:
- Intuition not lost, but gradually transformed
- Processes, language, power, culture gradually adjusts

In the right direction

Lead naturally to demand for the next step,
not to a dead end

# Some dead ends



# Dead ends

## Financial option analogy to real options analysis

Find and use the financial option formula that applies best to the real asset situation being considered

## MAD real options analysis

Use the value of "asset without options" to define the scenarios in an ROA of the asset with options

Do a DCF simulation of the "asset without options" and use the resulting expected NPV and uncertainty as parameters in the scenario risk adjustments

## Problems with these methods

**Financial option formulae usually not useful**

Financial contracts too simple to be good analogies for most real assets

**"Asset without options" usually not useful as an "underlying asset" in an ROA**

"Asset without options" usually not well defined

Most project-like assets too complex for this role

- Project value process too complex
- Project value depends on project cash-flow, not vice versa
- Project value not good as a policy variable

# More problems with these methods

Do not capture effects of differential discounting

Focus only of special types of flexibility

Too restrictive a modelling environment

Not easy to extend to a next step in right direction

# Final remarks

Plenty of work needed on complete decision trees

- Economic modelling and parameterisation
  - of input and output prices and price indices
- Asset models
- Computational methods, data presentation

Work needed on MBV

- Economic modelling and parameterisation
  - of risk adjustments
- Data presentation

Tools development needed

Good education and training programmes needed

Organisational issues