

# A Statistical Analysis of Production Decline Rates in the UKCS

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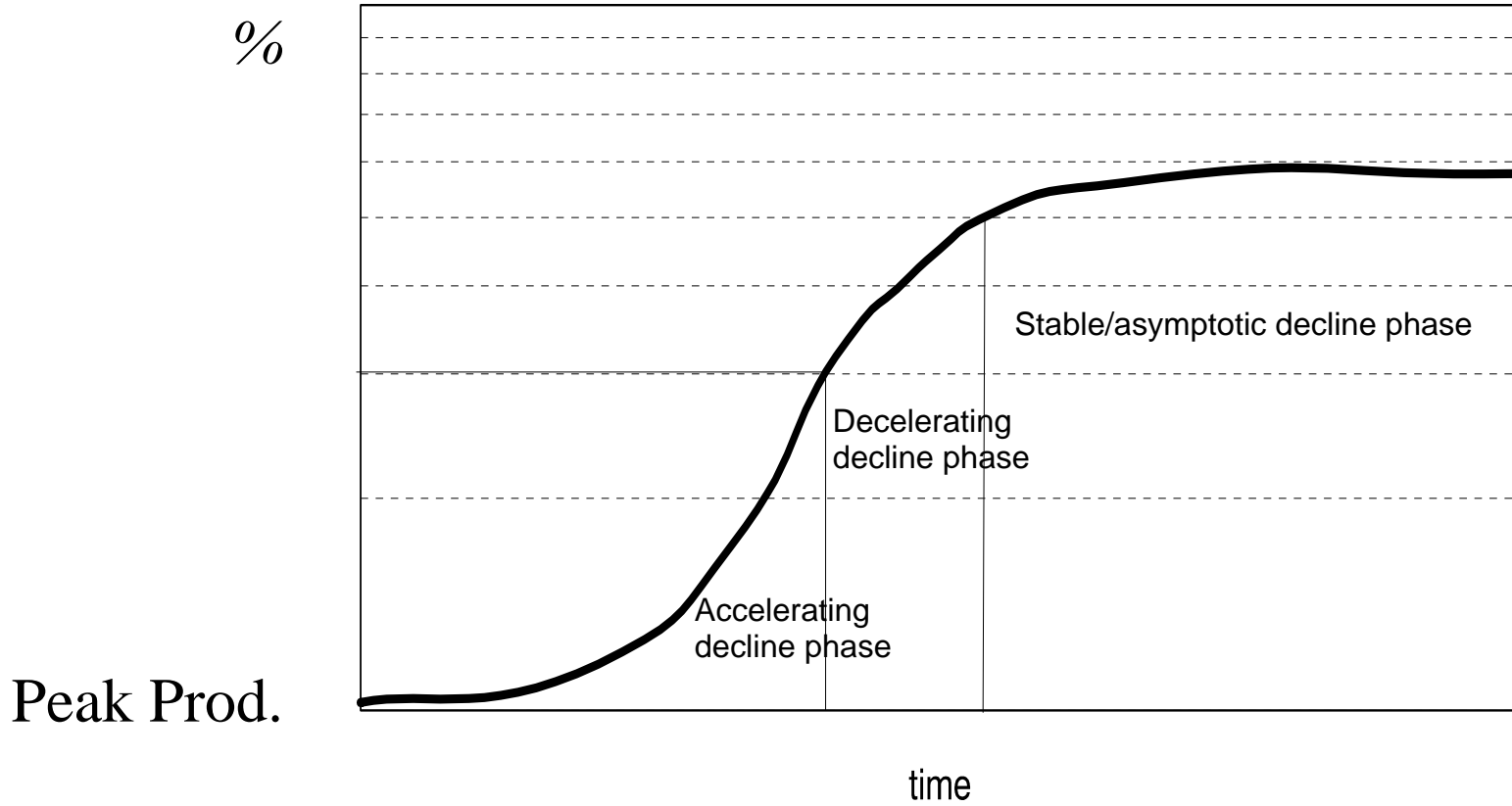
*Schlumberger Professor of*

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# **An Appropriate Mathematical Models of Decline Rates**

- 3 alternative models (linear, logistic and exponential) of production decline were considered in a curve-fitting exercise.
- The model with the highest R-square statistic was adjudged the best-regressed, capable of better explaining historical trends and predicting future decline rates.
- The data used are contained in a database which holds detailed information on 248 sanctioned UKCS fields. The database has been validated by UKCS field operators.

Fig. 1: HYPOTHETICAL LOGISTIC CURVE



The results are summarised as:

### Summary of Best-Fit Models

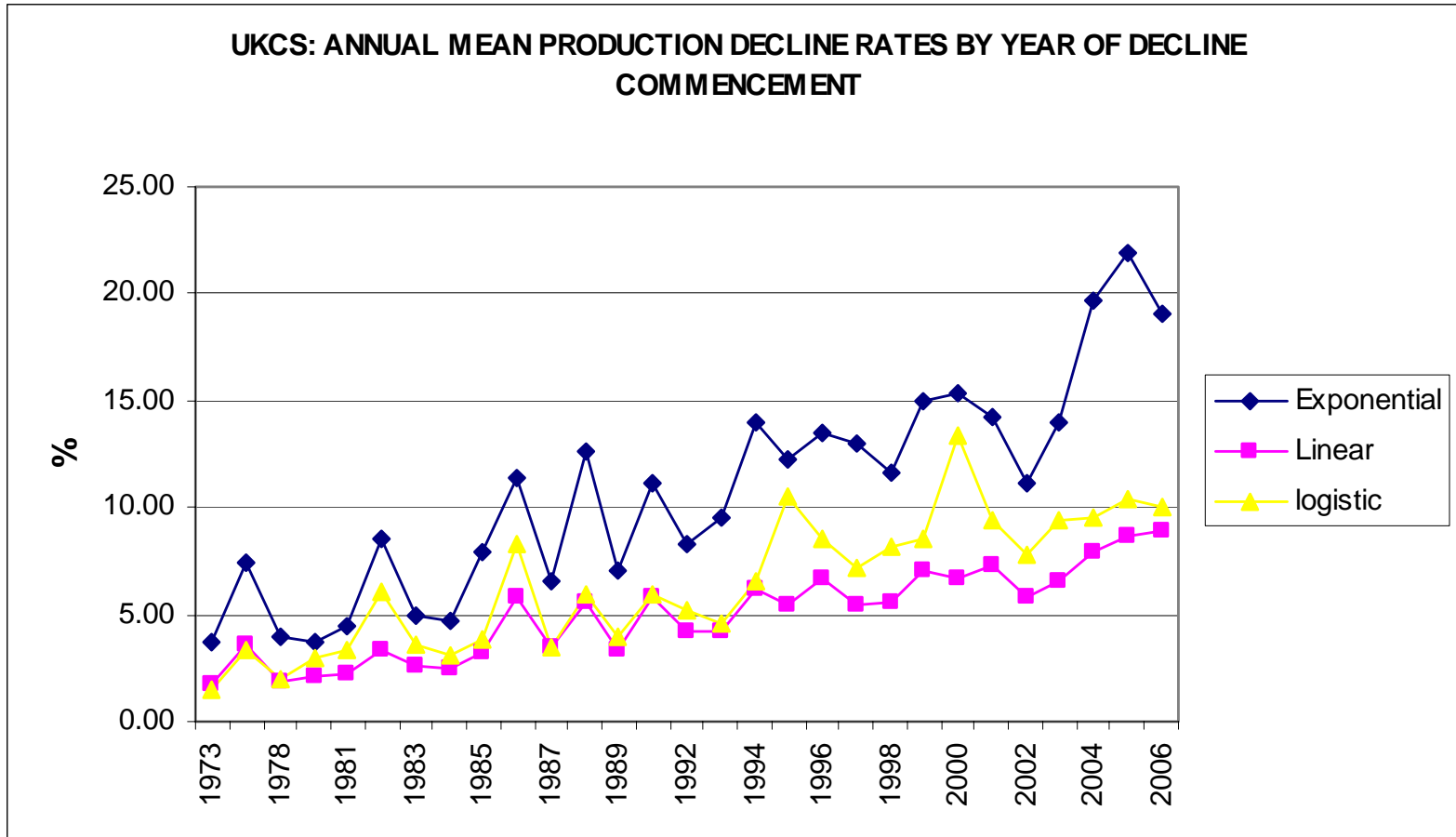
<b>Model</b>	<b>Relative number of cases (%)</b>
Logistic	67.26
Linear	26.99
Exponential	5.75
Total	100.00

## Best-Fit Models By Field Vintage

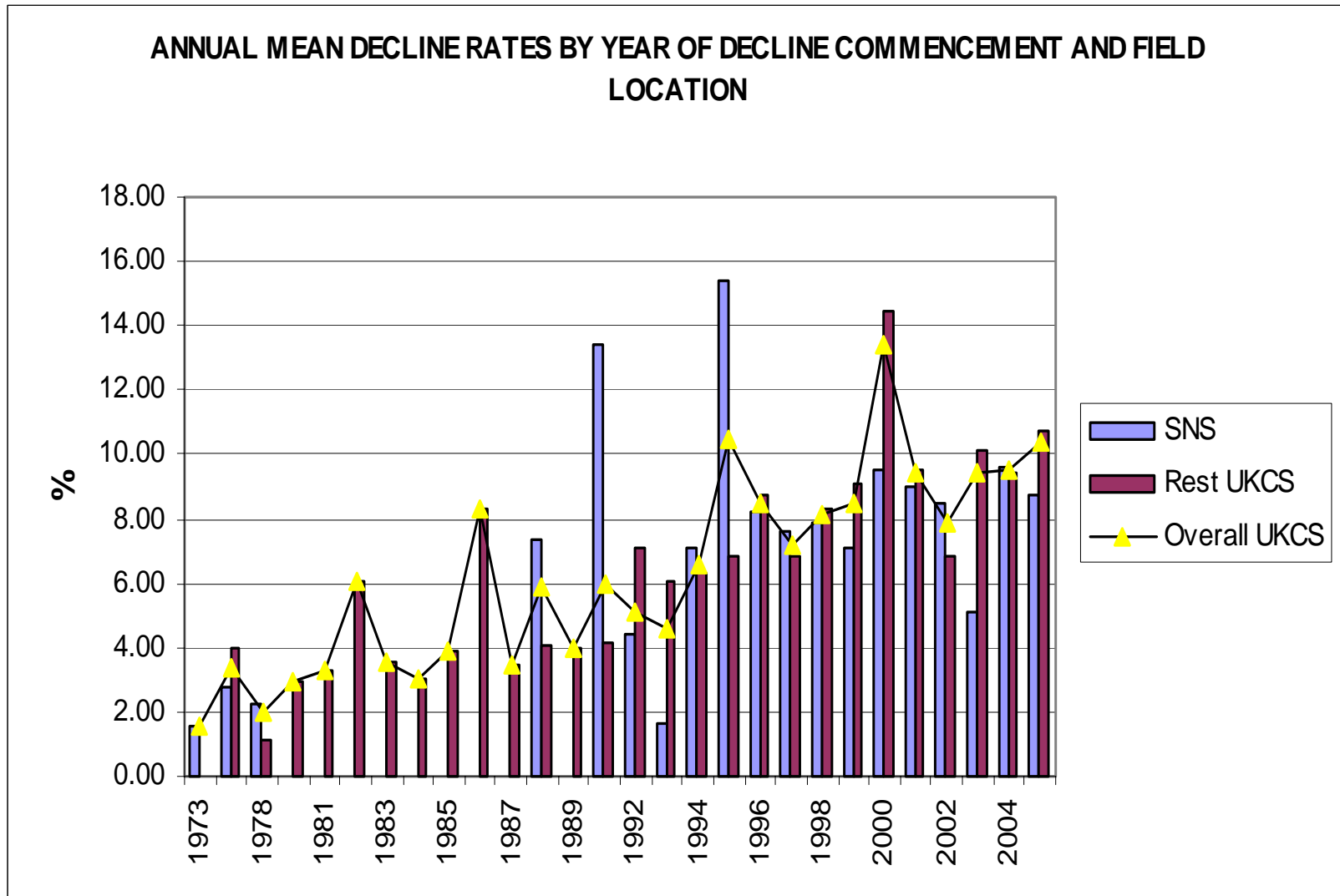
Field Vintage	Best-fit models (% of cases)			Total
	Logistic	Linear	Exponential	
Pre - 1970	66.67	33.33	0.0	100.00
1970s	77.78	22.22	0.0	100.00
1980s	63.46	26.92	9.62	100.00
1990s	65.25	29.08	5.67	100.00
2000s	81.82	18.18	0.0	100.00

# Annual Mean Decline Rates

## Overall Decline Rates by the 3 Models



# A Breakdown of Decline Rates Using Logistic Decline



# RELATIONSHIPS

## Preliminary

- Qualitative and quantitative influencing factors were tested for their statistical significance on decline rates.
- Results of the tests on the qualitative variables are as follows:

## Possible Qualitative Determinants of Decline Rates – Results of One-way ANOVA Tests

Variable	F-statistic	Significance of F	Remarks
Field vintage	5.531	0.0	Significant
Reservoir age	0.389	0.885	Not significant
Field location	0.745	0.389	Not significant
Resource type	1.681	0.189	Not significant

Results of the tests on the quantitative variables are as follows:

**Possible Quantitative Determinants of Decline Rates –  
Test Results of 2-Variable Regressions**

<b>Variable</b>	<b>t-statistic</b>	<b>Adjusted R-square</b>	<b>ANOVA (significance of F-statistic)</b>	<b>Remarks</b>
Field life	-6.745	0.170	0.0	Significant
Water depth	0.062	-0.005	0.950	Not significant
Reserves	-3.167	0.040	0.002	Significant

## Detailed Analyses

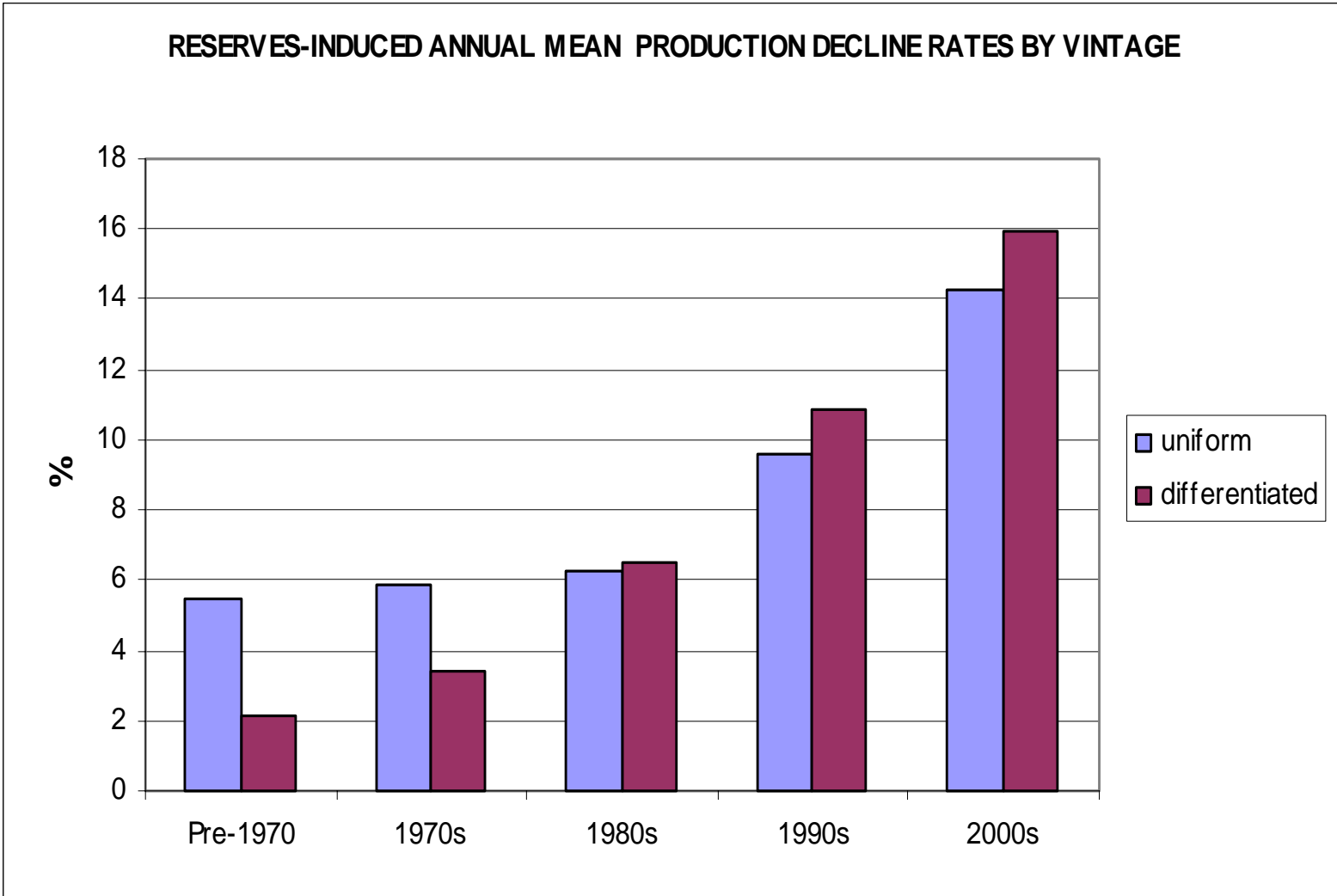
Building on the preliminary findings and using ANCOVA (analysis of co-variance) models, detailed investigations were carried out into the effects of the following on decline rates:

- the interplay of reserves and field vintage
- the interplay of post-peak investment and field vintages
- incremental investment in EOR, in-fill drilling etc.

## Effects of Reserves and Vintages on Decline Rates

- **Assumption 1:** Uniform responsiveness – even though the initial decline rates of the various field vintages may differ, once the decline process has commenced, the rate of decline with respect to available additional reserves is the same.
- **Assumption 2:** Differentiated responsiveness – both the starting points of decline rates and sensitivity to available additional reserves varying among the field vintages.

The following annual mean decline rates and rates of change of decline rates were derived from the regression results.



## Marginal Reserves-Induced Decline Rates

Vintage	Estimated Slope Coefficients	
	Uniform	Differentiated
Pre-1970	-0.0033	-0.0001
1970s	-0.0033	-0.0002
1980s	-0.0033	-0.0048
1990s	-0.0033	-0.0171
2000s	-0.0033	-0.0230

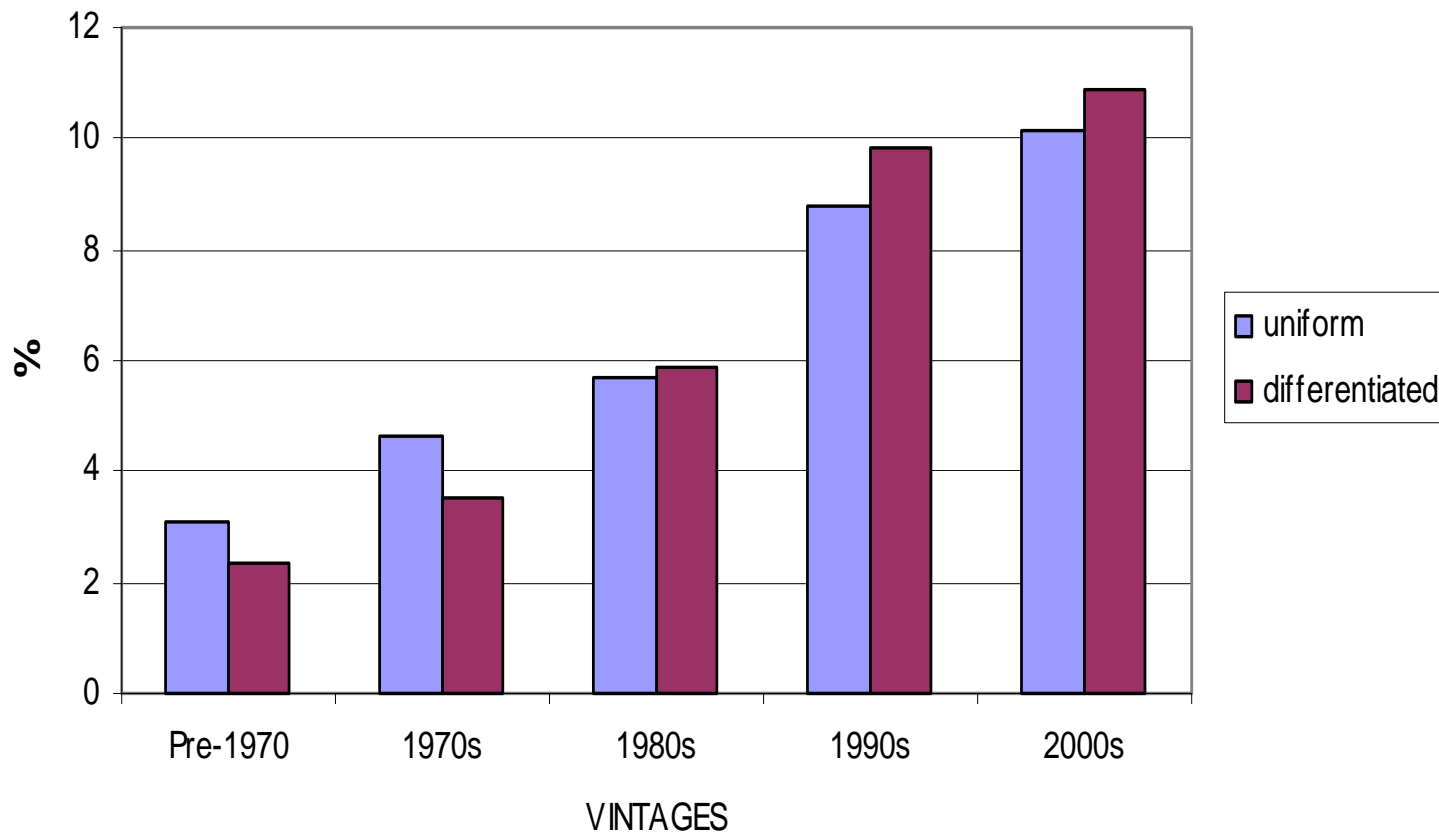
The results indicate that the newer fields have higher annual mean decline rates and higher (investment-induced) decline deceleration rates (suggestive of greater investment efficiency?)

## **Effects of Post-Peak Investment and Vintages on Decline Rates**

**Assumptions:** Same as above but replacing reserves with post-peak investment as the control variable.

The following annual mean decline rates and rates of change of decline rates were derived from the regression results

### POST-PEAK INVESTMENT-INDUCED ANNUAL MEAN PRODUCTION DECLINE RATES BY VINTAGE



## Marginal Post-Peak Investment-Induced Decline Rates

Vintage	Estimated Slope Coefficients	
	Uniform	Differentiated
Pre-1970	-0.0376	-0.0109
1970s	-0.0376	-0.0107
1980s	-0.0376	-0.0140
1990s	-0.0376	-0.0235
2000s	-0.0376	-0.0201

The results indicate that the newer fields have higher initial annual mean decline rates and (higher investment-induced) decline deceleration rates (suggestive of greater investment efficiency?)

## **Effects of Discrete Incremental Investment (infill drilling, EOR etc.)**

2 experiments were carried out to find out whether or not there are significant differences in the decline rates of:

- (a) fields with and without incremental investment (cross-section analysis)
- (b) pre- and post-incremental investment periods (time series analysis)

### *Result of cross-section analysis*

The regression results establish that the decline rates of the 2 groups are statistically different, with the rate being higher in the fields without incremental investment as follows:

## **Annual Mean Decline Rates**

Fields without incremental investment: 10.63%

Fields with incremental investment: 6.31%

### *Result of time series analysis*

In the vast majority of cases the differential intercepts and slopes in the two periods are statistically significant, implying that not only are the mean annual decline rates in the pre- and post- incremental investment periods different, but the responsiveness of decline rates to changes in remaining reserves are radically different in the two periods.

The post-incremental investment decline rates are lower than in the pre-investment period, suggesting that incremental investment does temper decline rates.

*Determinants of post-investment decelerating decline rates*

It was considered useful to investigate whether the observed reduction in the post-investment decline rates could be attributed to the size of incremental investment, field location etc.

The results of the ONE-WAY ANOVA statistical tests are as follows:

## Tests of Significance of Factors Influencing Decelerating Post-Investment Decline Rates

Variable	F	Sig. F	Remarks
Field vintage	2.729	0.055	Significant effect
Field location (6-area classification)	0.379	0.769	Not significant
Resource type	0.269	0.765	Not significant
Reserves size	degenerate solution		Not significant
Reservoir age	0.939	0.466	Not significant
Field location (2-area classification: SNS, Rest of UKCS)	0.056	0.814	Not significant
Size of incremental investment	0.165	0.686	Not significant
Field life	11.283	0.002	Significant

## Conclusions

The logistic decline model has been shown as being the one best able to describe the behaviour of decline rates in the majority of UKCS fields.

Newer fields start off at higher annual mean decline rates but exhibit a higher decline deceleration in the face of available additional reserves and/or investment (post-peak and incremental).

This property of newer fields poses a challenge to and an opportunity for UKCS operators and policymakers.