**University College Cork
Department of Civil & Environmental Engineering
Sustainable Energy Research Group**

# Evaluating the effectiveness of ODEX in measuring true energy efficiency achievements: Case study Irish Industry

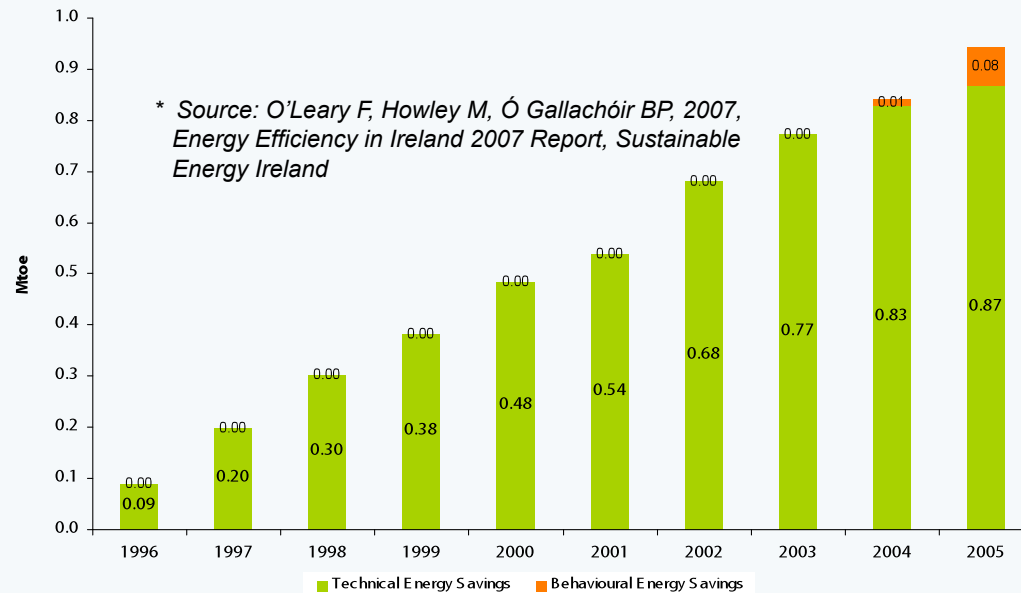**Caiman Cahill, Brian Ó Gallachóir
La Colle sur Loup, June 2009**

Coláiste na hOllscoile Corcaigh, Éire
University College Cork, Ireland

ENVIRONMENTAL RESEARCH INSTITUTE
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# Background

- EU ESD recommends use of ODEX in the harmonised calculation model to capture overall EE improvement
- Purpose of indicator: high-level indication of EE developments
- ODEX used to calculate official energy savings for year $n$ with the formula:

$$Savings_n = EC_n(1 - 100/ODEX_n)$$

\* Source: O'Leary F, Howley M, Ó Gallachóir BP, 2007, *Energy Efficiency in Ireland 2007 Report, Sustainable Energy Ireland*

Mtoe

| Year | Technical Energy Savings | Behavioural Energy Savings |
|------|--------------------------|----------------------------|
| 1996 | 0.09 | 0.00 |
| 1997 | 0.20 | 0.00 |
| 1998 | 0.30 | 0.00 |
| 1999 | 0.38 | 0.00 |
| 2000 | 0.48 | 0.00 |
| 2001 | 0.54 | 0.00 |
| 2002 | 0.68 | 0.00 |
| 2003 | 0.77 | 0.00 |
| 2004 | 0.83 | 0.01 |
| 2005 | 0.87 | 0.08 |

■ Technical Energy Savings ■ Behavioural Energy Savings

- Is this method of calculation valid? How reliable is the result?

# Comparing ODEX and Energy Intensity at Constant Structure (1)

- Irish industry: Large differences between values for ODEX and Energy Intensity at Constant Structure (Divisia).

- Difference between the two index values not explained by differences between GVA and production units alone.

- Ireland: GVA data and production output data closely related.
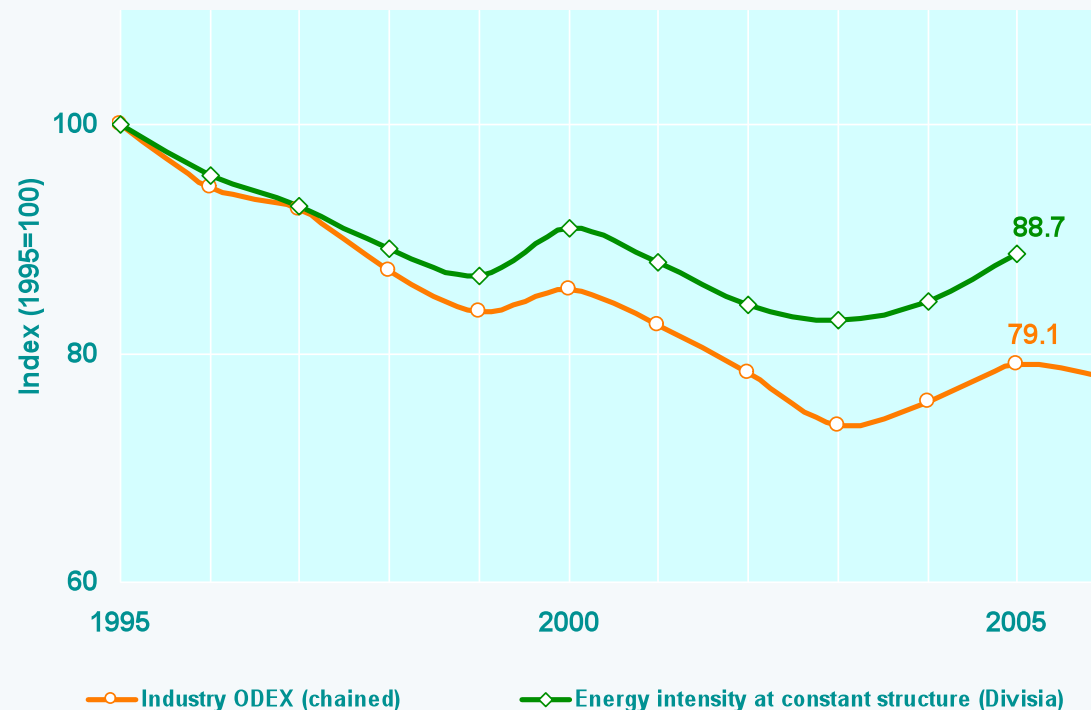
# Comparing ODEX and Energy Intensity at Constant Structure (2)

- Need to explain the large difference between the two values
- Three tests compare results of each of the two methods
- Tests examine appropriateness of using index value to calculate total savings

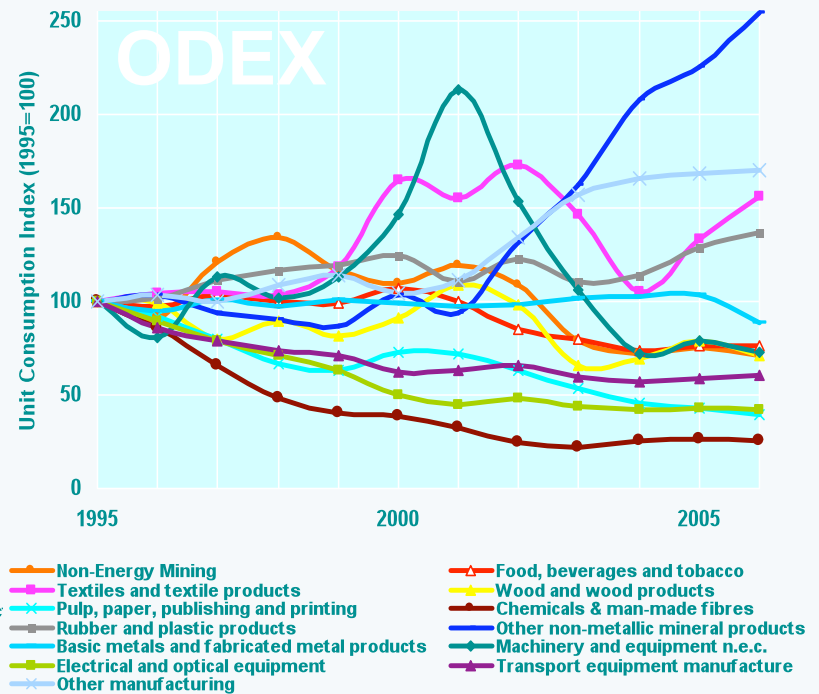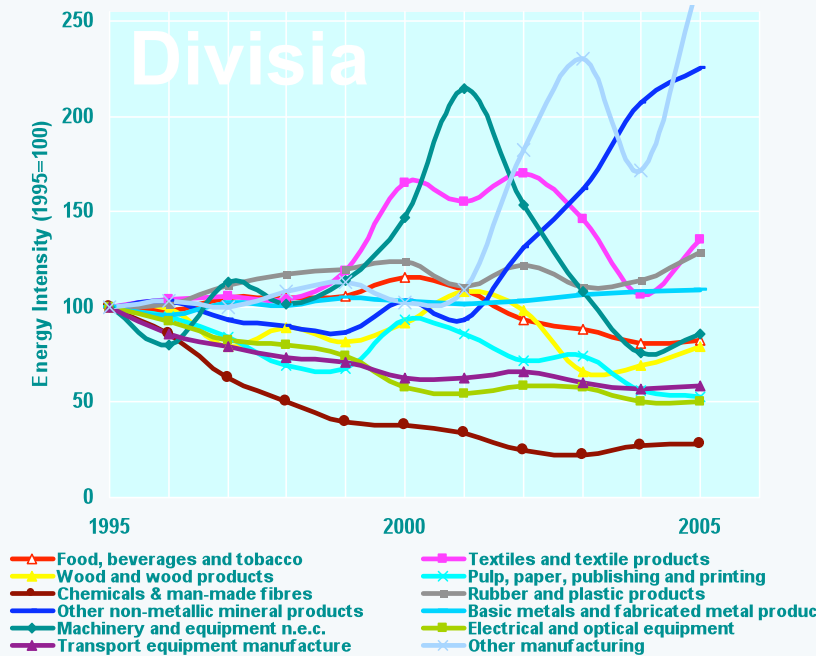# TEST 1: Index behaviour with fluctuating sub-sectoral indices (1)

- *TEST 1:* How do indices behave when the sub-sectoral values are fluctuating?
- Test scenario: Industry comprises two sub-sectors. Fluctuating sub-sectoral energy intensities/ unit consumption values
- Energy Intensity Index returns to original value
- Fluctuating unit consumption indices cause ODEX to drift.
- ODEX value has improved even though unit consumption values are unchanged.
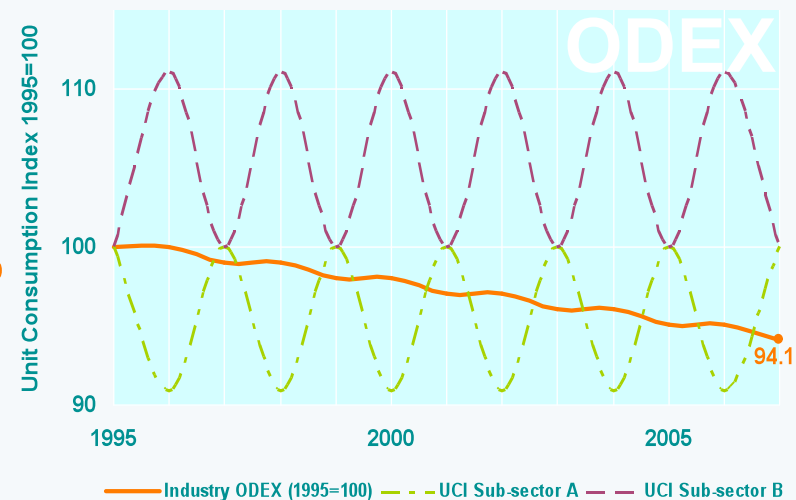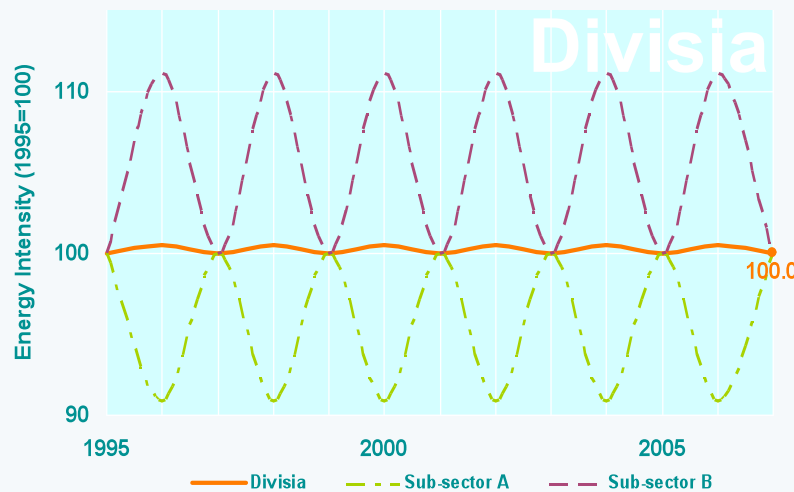
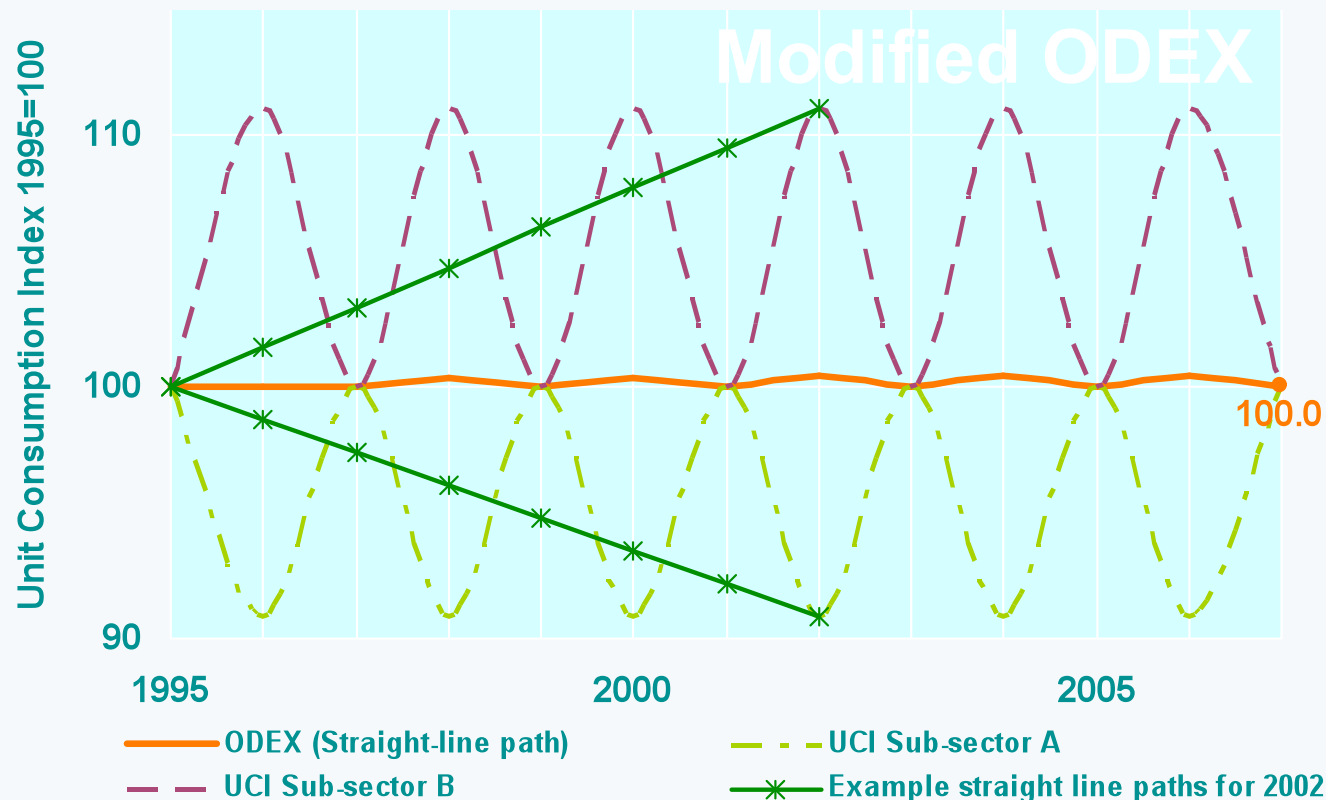# TEST 1: Index behaviour with fluctuating sub-sectoral indices (2)

- Relevance of test: Irish industry large fluctuations over 12 year period.
- Effect of fluctuations needs to be measured.

# TEST 1: Index behaviour with fluctuating sub-sectoral indices (3)

- Drift observed in ODEX can be reduced by calculating index in a different manner
- Modified ODEX uses a straight-line interpolation of UCI between base year and year *n*, for all years



**Modified ODEX**

Unit Consumption Index 1995=100

Legend:
- ODEX (Straight-line path)
- UCI Sub-sector B
- UCI Sub-sector A
- Example straight line paths for 2002

# TEST 1: Index behaviour with fluctuating sub-sectoral indices (4)

- Replacing fluctuating paths with straight line paths give some measure of the effect.
- Industry ODEX for 2006 is 2.6 percentage points worse when using straight-line method, while EI index remains the same.
- Therefore ODEX value is path-dependent, EI value is not.
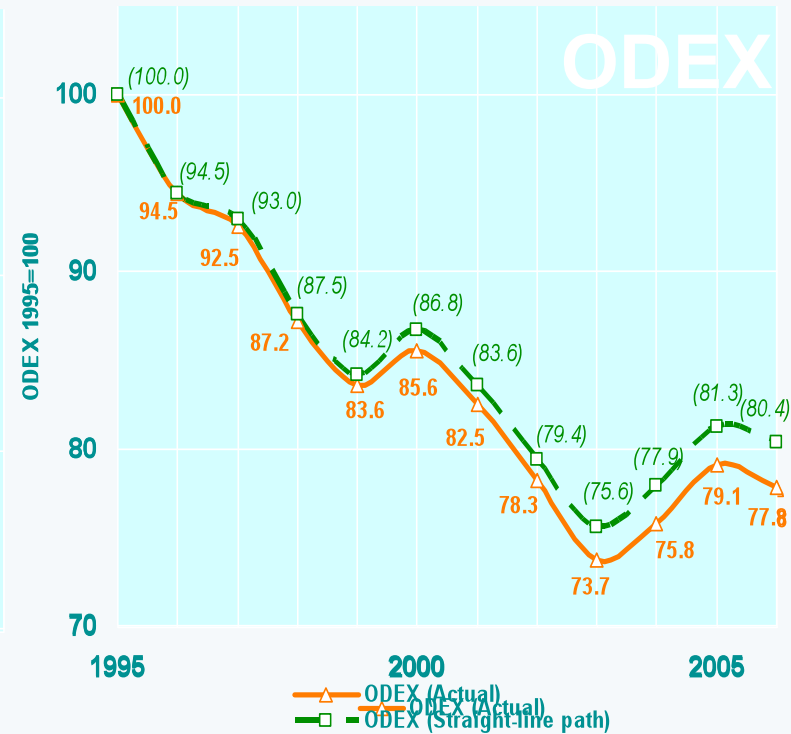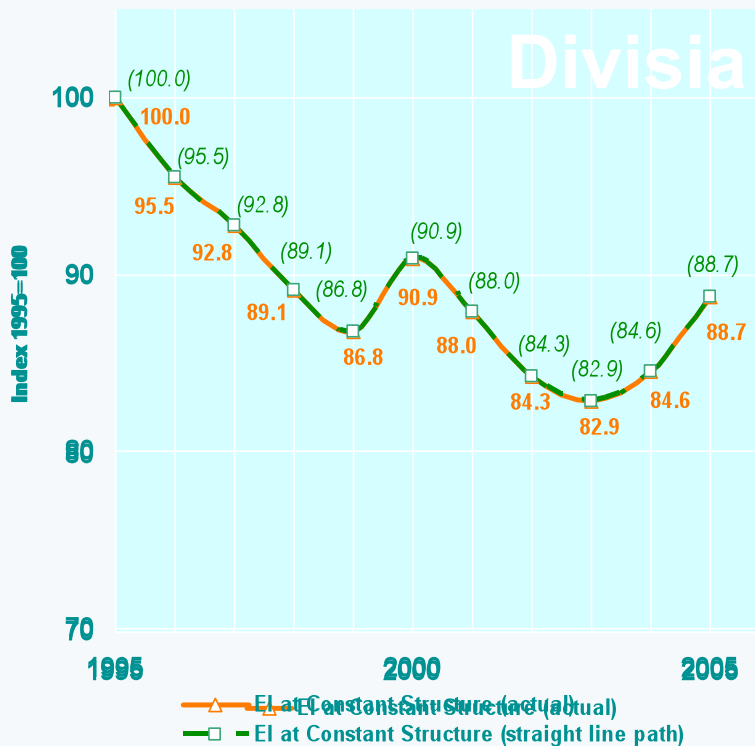
# TEST 2: Index number theory-
## Time reversal test (1)

- Formal index number theory tests provide an indication of the reliability of the index result.

- *Diewert (1993)\** lists 9 tests that have been used to examine the accuracy of indices in index number theory
    - Identity test
    - Proportionality test
    - Invariance to changes in scale test
    - Invariance to changes in units
    - Time reversal test
    - Commodity reversal test
    - Monotonicity test
    - Mean value test
    - Circularity test

- *Time reversal test:* If we reverse the time sequence between years *n* and *0,* the new index should be the reciprocal of the original

\* *Diewert W.E., 1993, Chapter 5 Index Numbers, Essays in Index Number Theory,*
  *Vol. 1, Elsevier Science Publishers*

# TEST 2: Index number theory-
# Time reversal test (2)

- *TEST 2:* Perform a time reversal test to see if index follows path to original value.
- Test shows that Divisia returns to original value
- ODEX yields a different (lower) value.
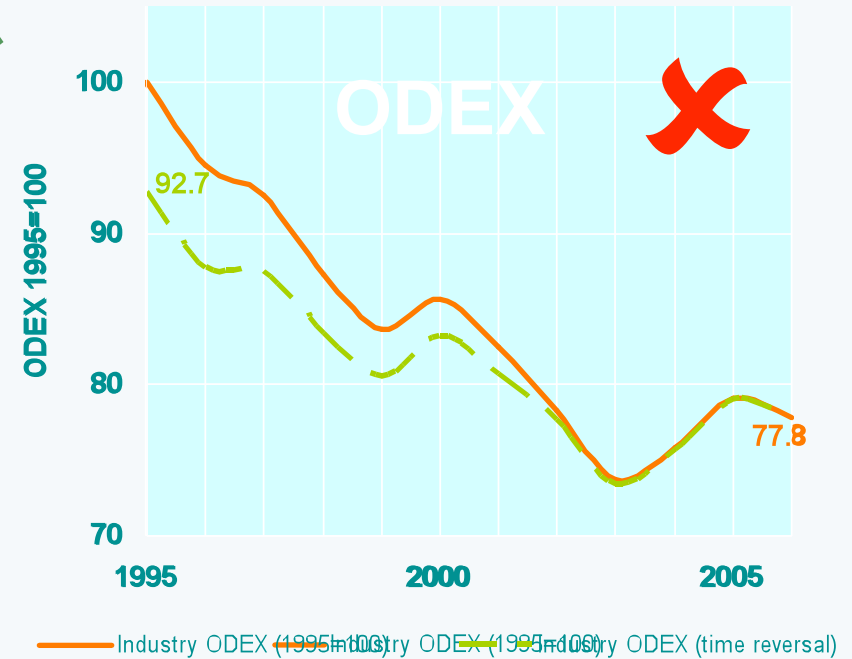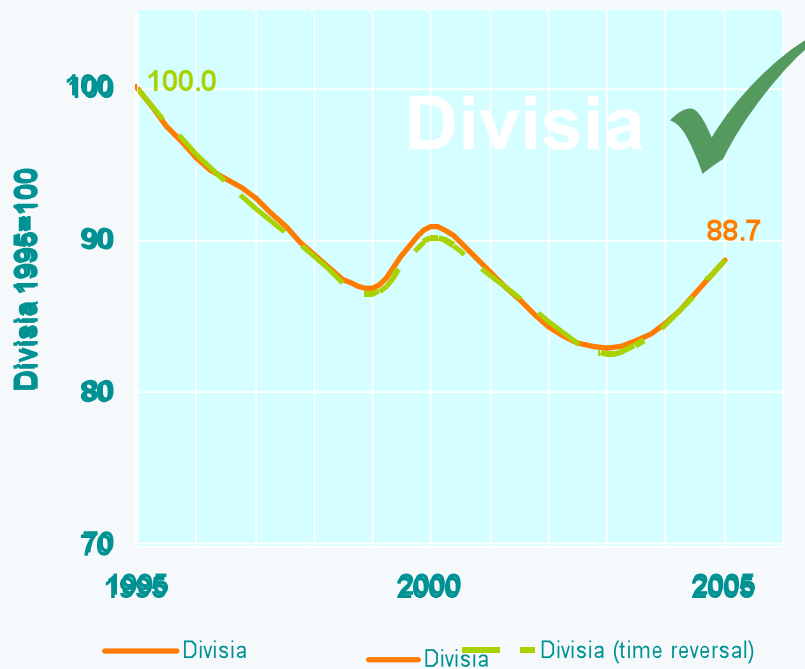
## TEST 3: Effectiveness of index in capturing early EE improvements (1)

- EU ESD allows inclusion of savings achieved as early as 1995 (or 1991 in some cases)
- Does an index adequately reflect the longer-term effects of early energy efficiency changes?
- *TEST 3:* Analyse the effect of energy efficiency changes for each sub-sector for each year on the index values for all subsequent years

## TEST 3: Effectiveness of index in capturing early EE improvements (2)

- Example 1: Effect of EE improvements in *NACE 24 Chemicals* achieved in 1996 is analysed for all subsequent years.
- Divisia: 1996 improvement contributes a 0.7 percentage point reduction (or 6.2% of total improvement) in 2005.
- ODEX: 1996 improvement is having a negative impact (0.1 to 0.3 percentage points) on the index from 2002 onwards.
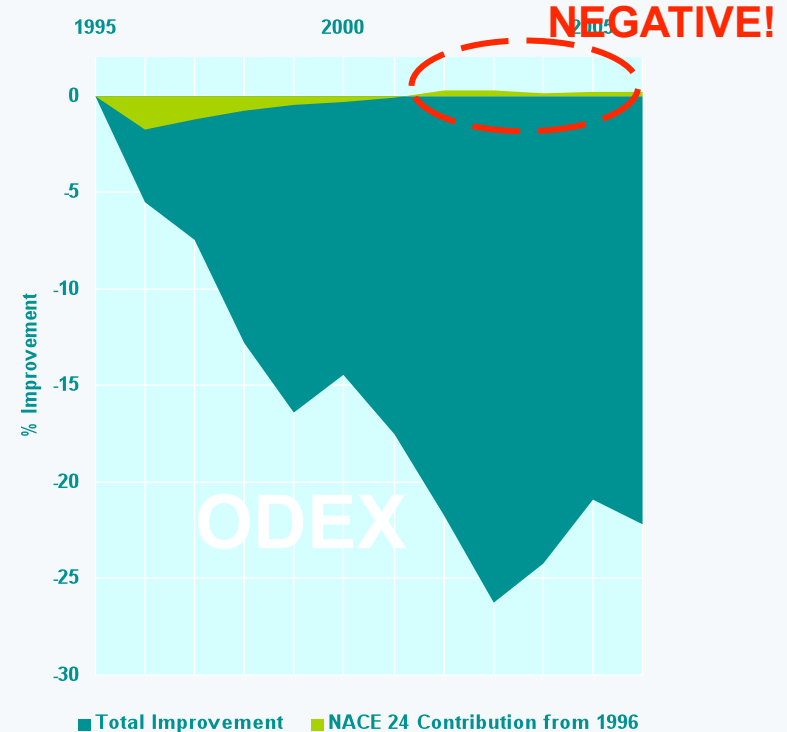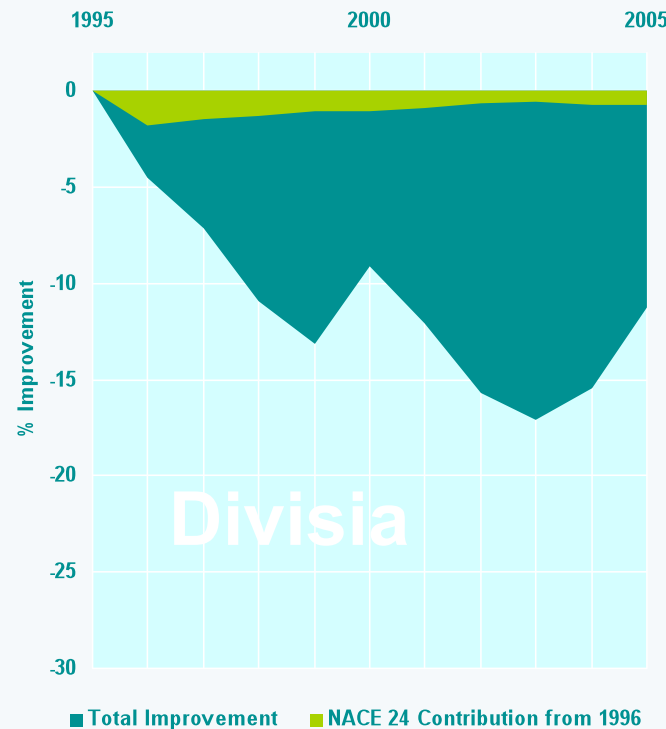
## TEST 3: Effectiveness of index in capturing early EE improvements (3)

- Example 2: Effect of EE improvements in all sub-sectors combined in 1997 is analysed for all subsequent years.

- Divisia: 1997 shows 2.5% improvement causing a 0.7 percentage point reduction by 2001.

- ODEX: Records a 1.9% improvement in EE in 1997 resulting in a 1.1% deterioration in the index by 2001.
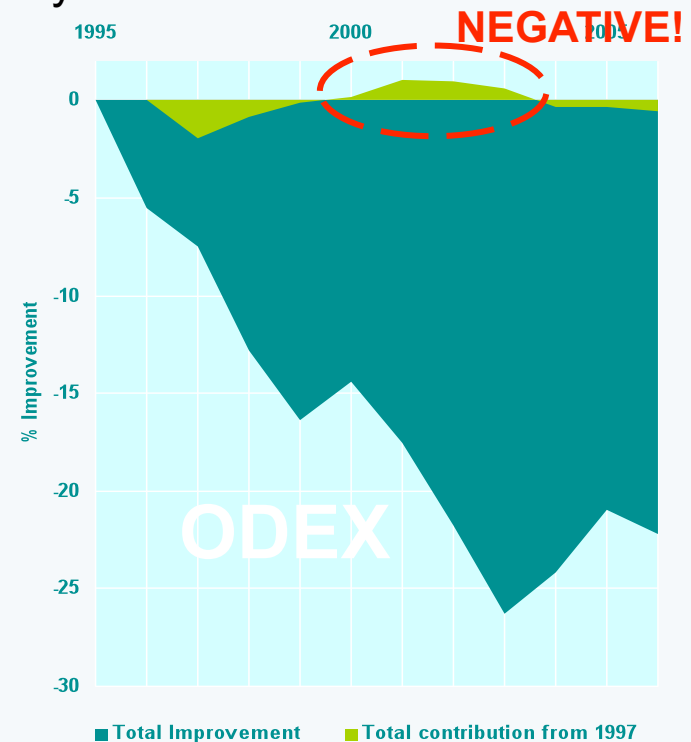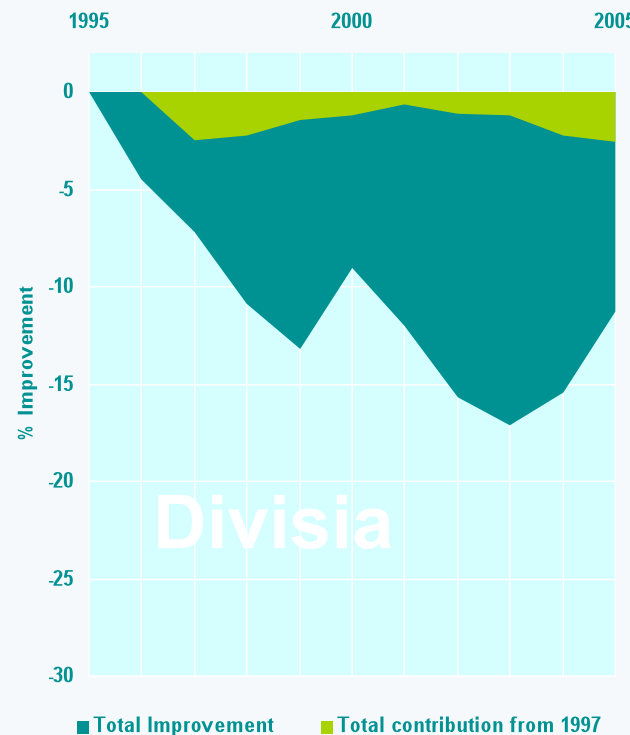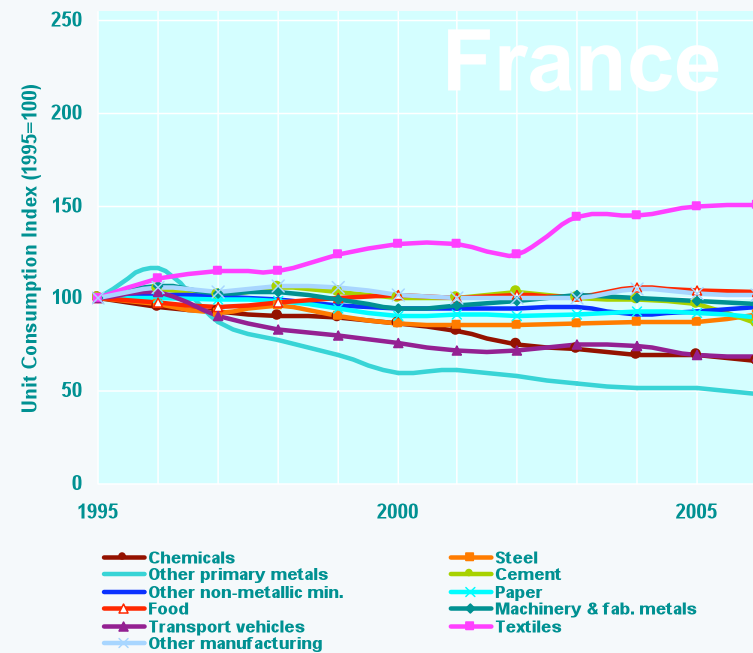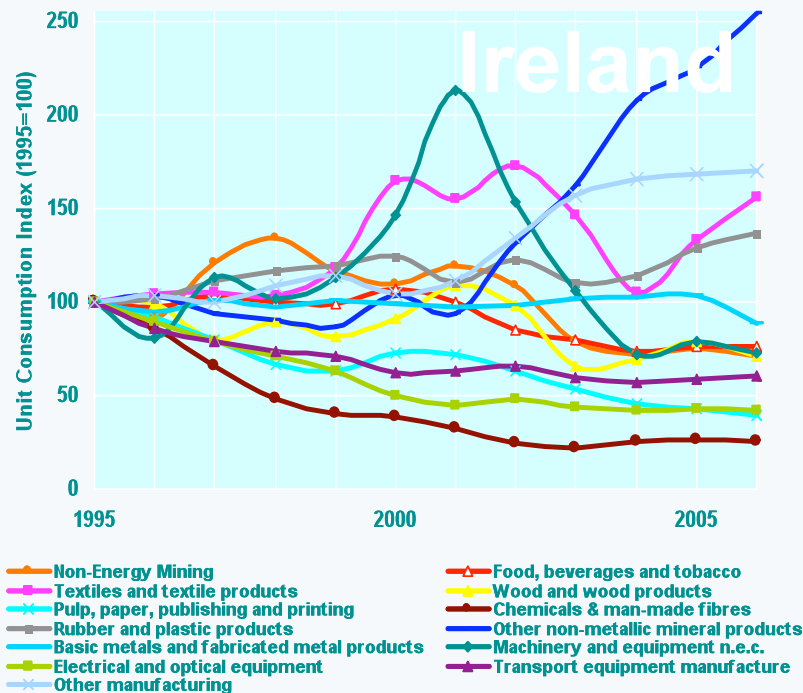
# Comparing Ireland & France

- Need to determine if observed ODEX issues are specific to the Irish data set.

- For comparison purposes, ODEX calculation for France is subjected to same tests

- For France, far less divergence between ODEX and Divisia
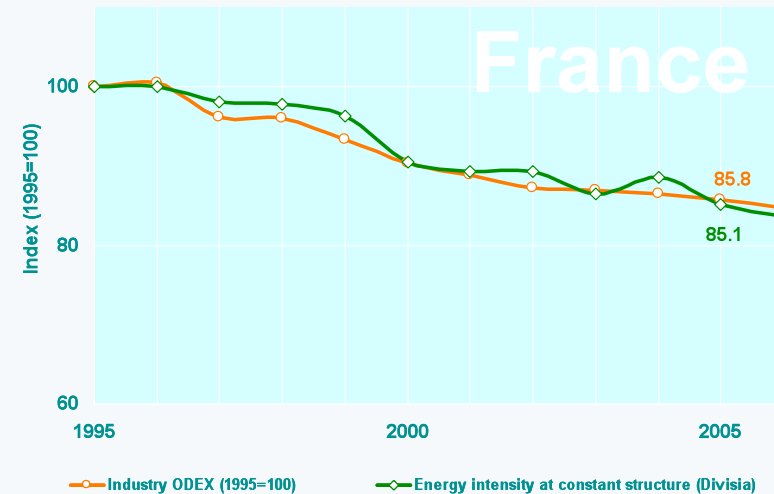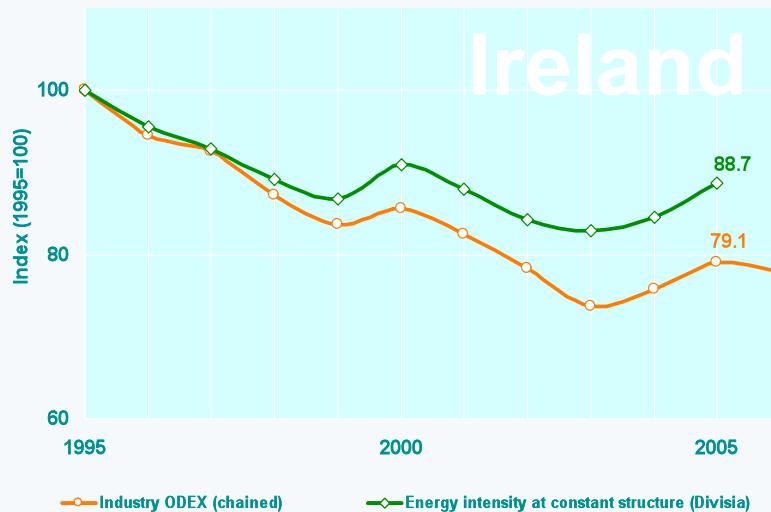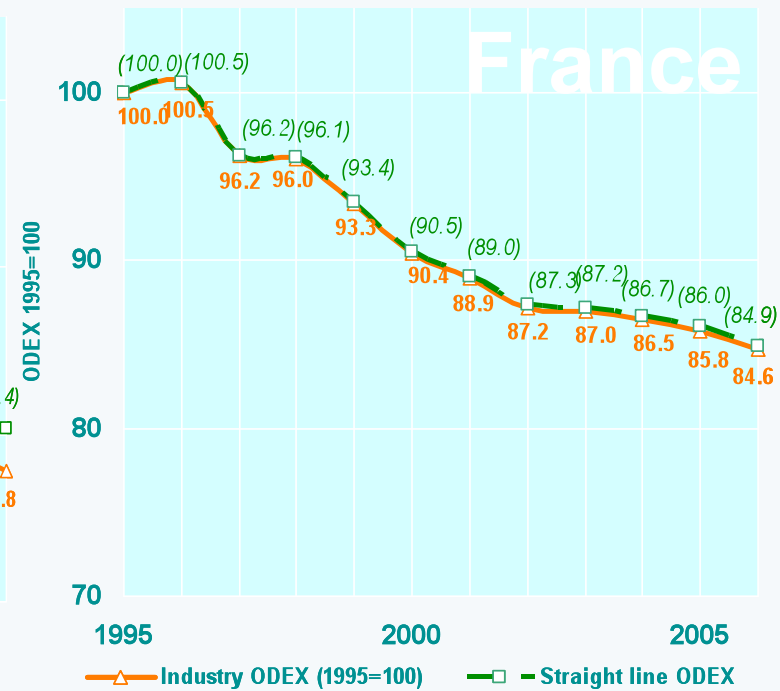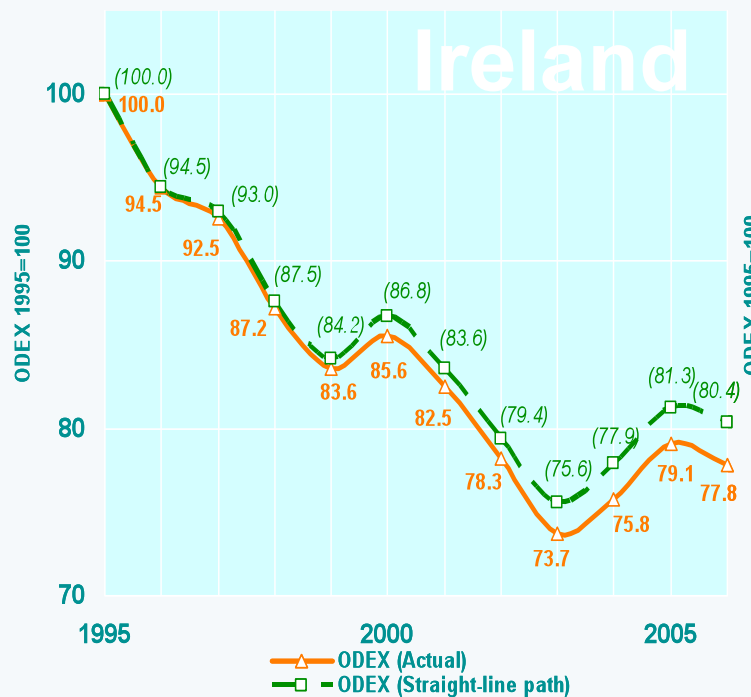
# Ireland & France: Test 1

- Sub-sectoral unit index fluctuations a key contributor to inaccurate ODEX calculation
- French sub-sectoral values exhibit much smaller levels of fluctuation



Legend (Ireland):
- Non-Energy Mining
- Textiles and textile products
- Pulp, paper, publishing and printing
- Rubber and plastic products
- Basic metals and fabricated metal products
- Electrical and optical equipment
- Other manufacturing
- Food, beverages and tobacco
- Wood and wood products
- Chemicals & man-made fibres
- Other non-metallic mineral products
- Machinery and equipment n.e.c.
- Transport equipment manufacture

Legend (France):
- Chemicals
- Other primary metals
- Other non-metallic min.
- Food
- Transport vehicles
- Other manufacturing
- Steel
- Cement
- Paper
- Machinery & fab. metals
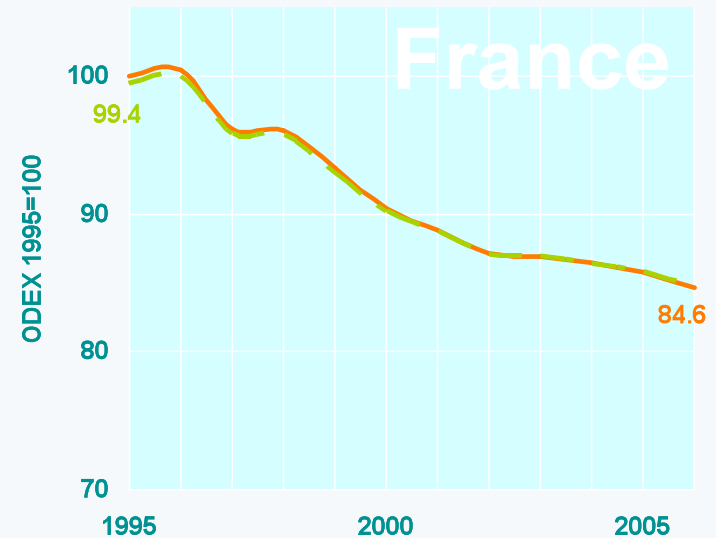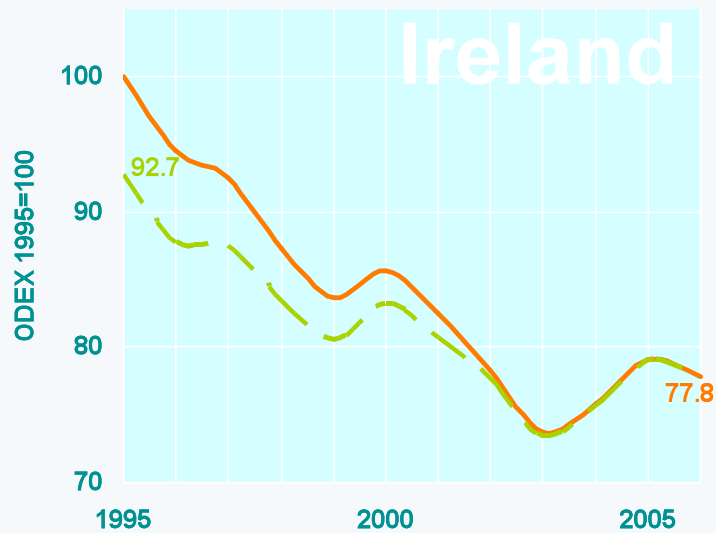- Textiles

# Ireland & France: Test 1

- Straight line method for calculating ODEX for France gives a 0.3 point higher value for 2006
- This compares to a 2.6 point difference for Ireland

# Ireland & France: Test 2

- Time reversal test for French data returns a gives a 0.6 point error for the period analysed, compared with a 7.3 point error for Ireland for the same period.

# Ireland & France: Test 3
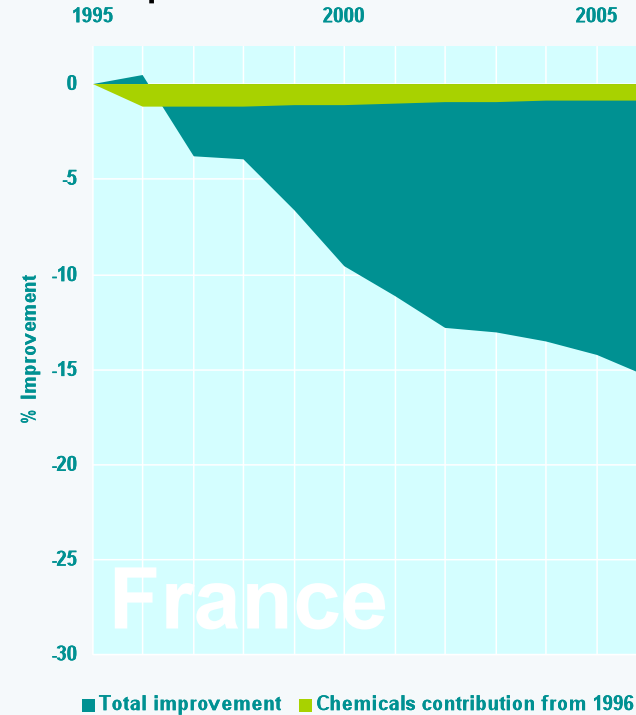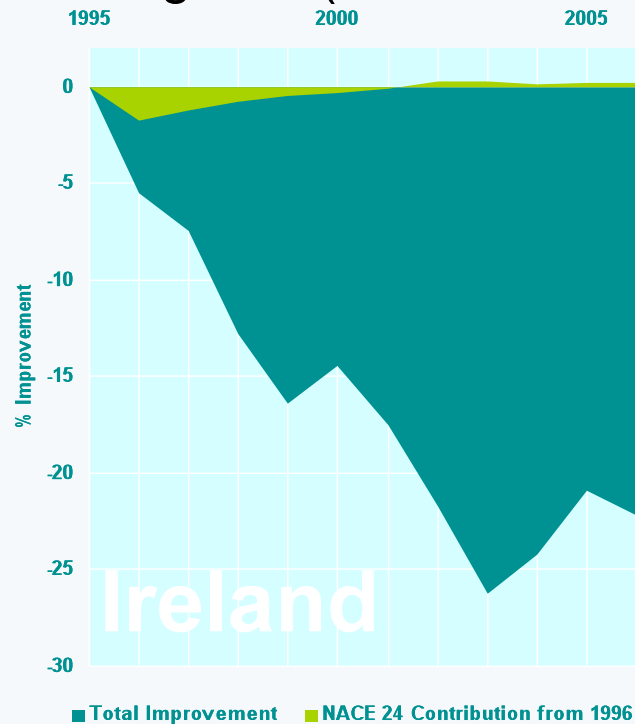
- For every year, each sub-sector's contribution to ODEX for France is analysed

- Each contribution shows gradual change from year to year

- No French sub-sector's contribution changes from positive to negative (or vice versa) for the period examined

# In conclusion…

- Divisia performs better than ODEX when subjected to tests

- Fluctuations of subsector data leads to errors in ODEX result, similar fluctuations have no effect on Divisia result

- Divisia provides a better measure of EEI for Irish industry

- ODEX performance improves when using French Industry data

- Appropriateness of using ODEX should be assessed on a country-by-country basis

- ODEX should be used to measure EEI and calculate national energy savings only if performance can be proven to be acceptable

- However, acceptable performance of ODEX in the past does not guarantee error-free performance in future

# Thank You

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