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# An Ex-post Analysis of the 2008 Car Tax Change on Private Vehicle $CO_2$ Emissions and Tax Revenue

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**Institution :** Energy Policy & Modelling Group, MaREI, UCC
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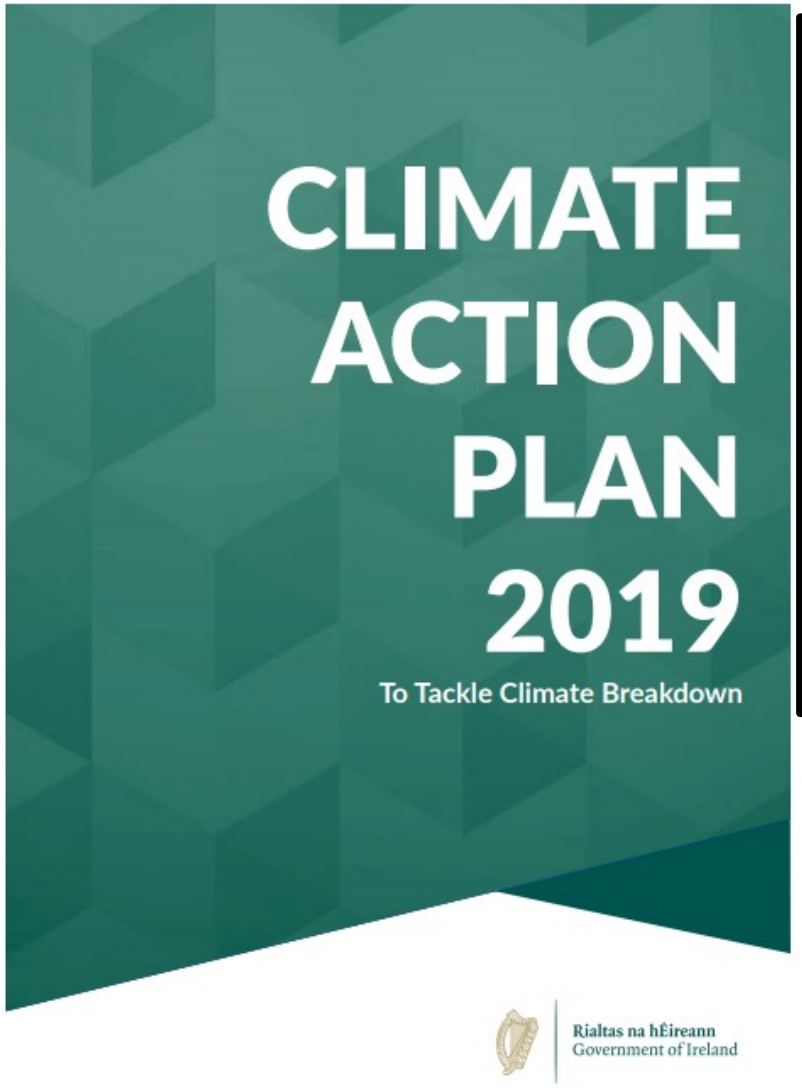
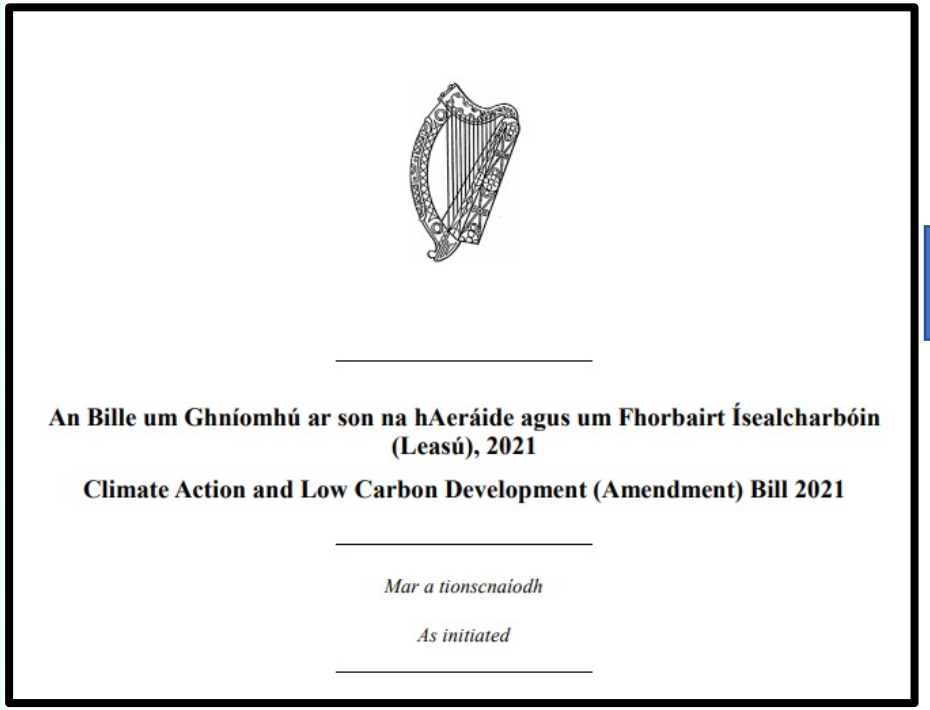
# Ireland's commitments to Climate Action



An Bille um Ghníomhú ar son na hAeráide agus um Fhorbairt Ísealcharbóin (Leasú), 2021

Climate Action and Low Carbon Development (Amendment) Bill 2021

*Mar a tionscnaíodh*

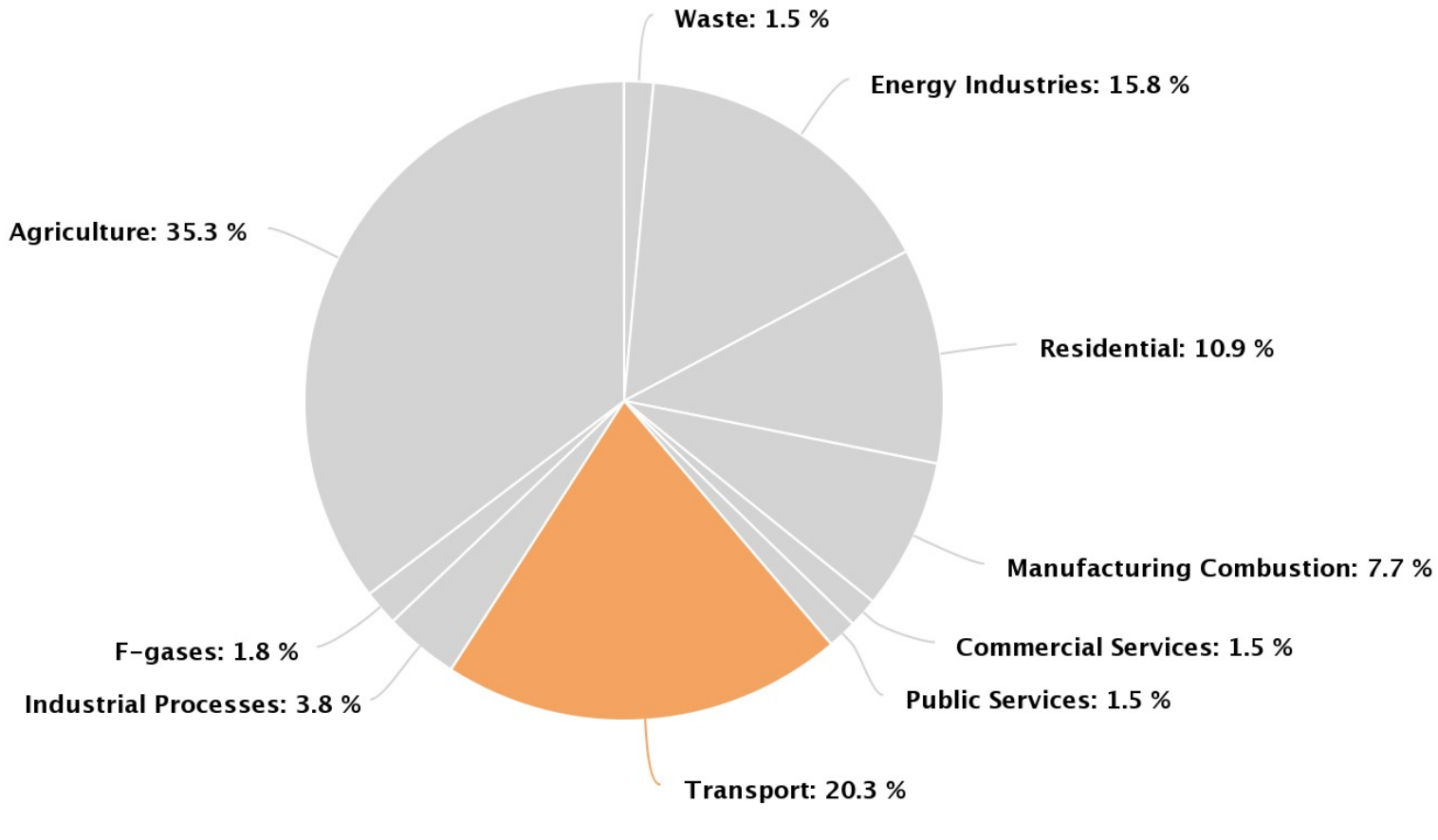
*As initiated*

A legal obligation to a 51% reduction in GHG emissions for Ireland by 2030 compared to 2020.

This roughly translates to 7% per year reduction in GHG emissions


Targets for sustainable technologies, public services and low carbon schemes

# Policy Context




[1] Environmental Protection Agency, 2021 accessible at https://www.epa.ie/ghg/transport/

# *Policy Makers & Energy System Modellers*

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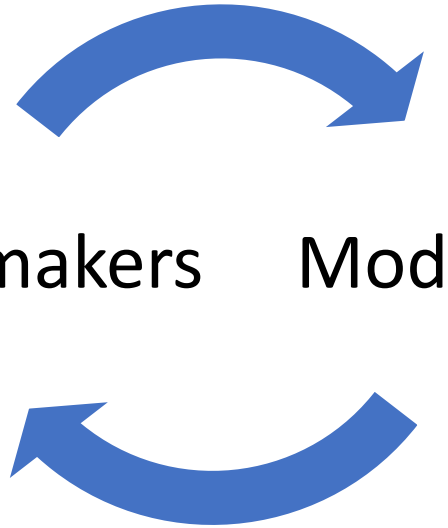
## Knowledge areas

- Policy documents
- Needs of the public
- Emissions targets
- Modelling blind spots



Policy makers  Modellers

## Knowledge areas

- Modelling Tools
- Analytical capacity
- Policy blind spots

# Context

## Engine CC based tax

| Engine CC | Annual Payment | Engine CC | Annual Payment |
|---|---|---|---|
| Not over 1,000 | €199 | 2,001-2,100 | €906 |
| 1,001-1,100 | €299 | 2,101-2,200 | €951 |
| 1,101-1,200 | €330 | 2,201-2,300 | €994 |
| 1,201-1,300 | €358 | 2,301-2,400 | €1034 |
| 1,301-1,400 | €385 | 2,401-2,500 | €1080 |
| 1,401-1,500 | €413 | 2,501-2,600 | €1294 |
| 1,501-1,600 | €514 | 2,601-2,700 | €1345 |
| 1,601-1,700 | €544 | 2,701-2,800 | €1391 |
| 1,701-1,800 | €636 | 2,801-2,900 | €1443 |
| 1,801-1,900 | €673 | 2,901-3,000 | €1494 |
| 1,901-2,000 | €710 | 3,001 or more | €1809 |

## Emissions based tax

| Band | $CO_2$ emissions-grams per km | Annual Payment |
|---|---|---|
| A0 | 0 | €120 |
| A1 | 1-80g | €170 |
| A2 | More than 80g/km up to and including 100g/km | €180 |
| A3 | More than 100g/km up to and including 110g/km | €190 |
| A4 | More than 110g/km up to and including 120g/km | €200 |
| B1 | More than 120g/km up to and including 130g/km | €270 |
| B2 | More than 130g/km up to and including 140g/km | €280 |
| C | More than 140g/km up to and including 155g/km | €390 |
| D | More than 155g/km up to and including 170g/km | €570 |
| E | More than 170g/km up to and including 190g/km | €750 |
| F | More than 190g/km up to and including 225g/km | €1200 |
| G | More than 225g/km | €2350 |

# An Ex-post analysis of Ireland's 2008 Car tax change – why does it matter?

- Today, 24 EU countries levy car taxes partially or totally based on the CO2 emissions and/or fuel consumption of a vehicle.

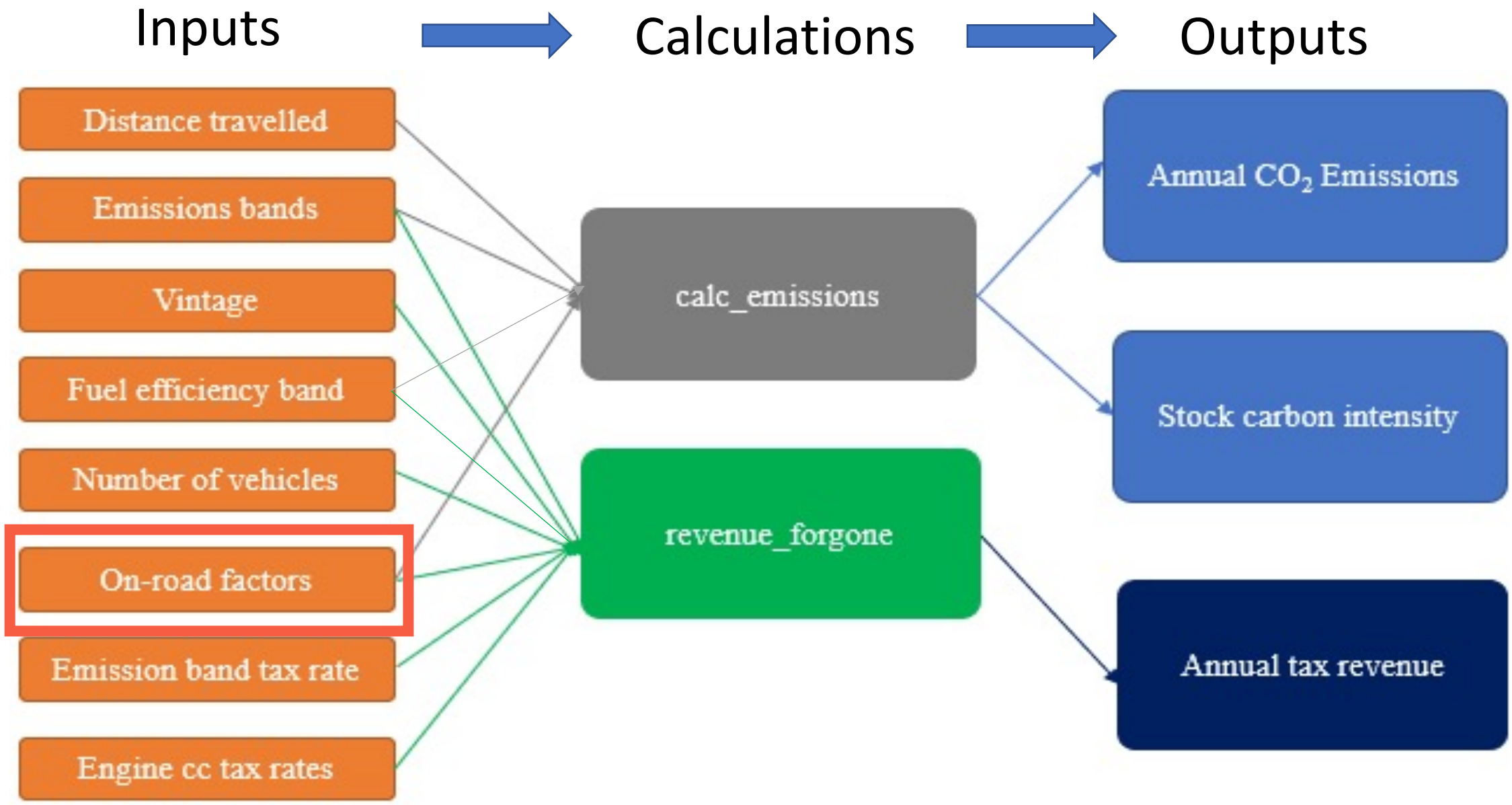
- Ex-post analysis help us reflect and improve past policies. This policy is still in place – what are the unintended consequences of the policy?

# Irish Car Stock Model [1]

- Bottom up technology stock model of cars in Ireland
- Has a list of cars by:
    1. Engine cc
    2. Fuel consumption
    3. Age
    4. Fuel type

[1] H. Daly and B. P. Ó Gallachóir, "Modelling private car energy demand using a technological car stock model," *Transp. Res. Part D Transp. Environ.*, 2011, doi: 10.1016/j.trd.2010.08.009

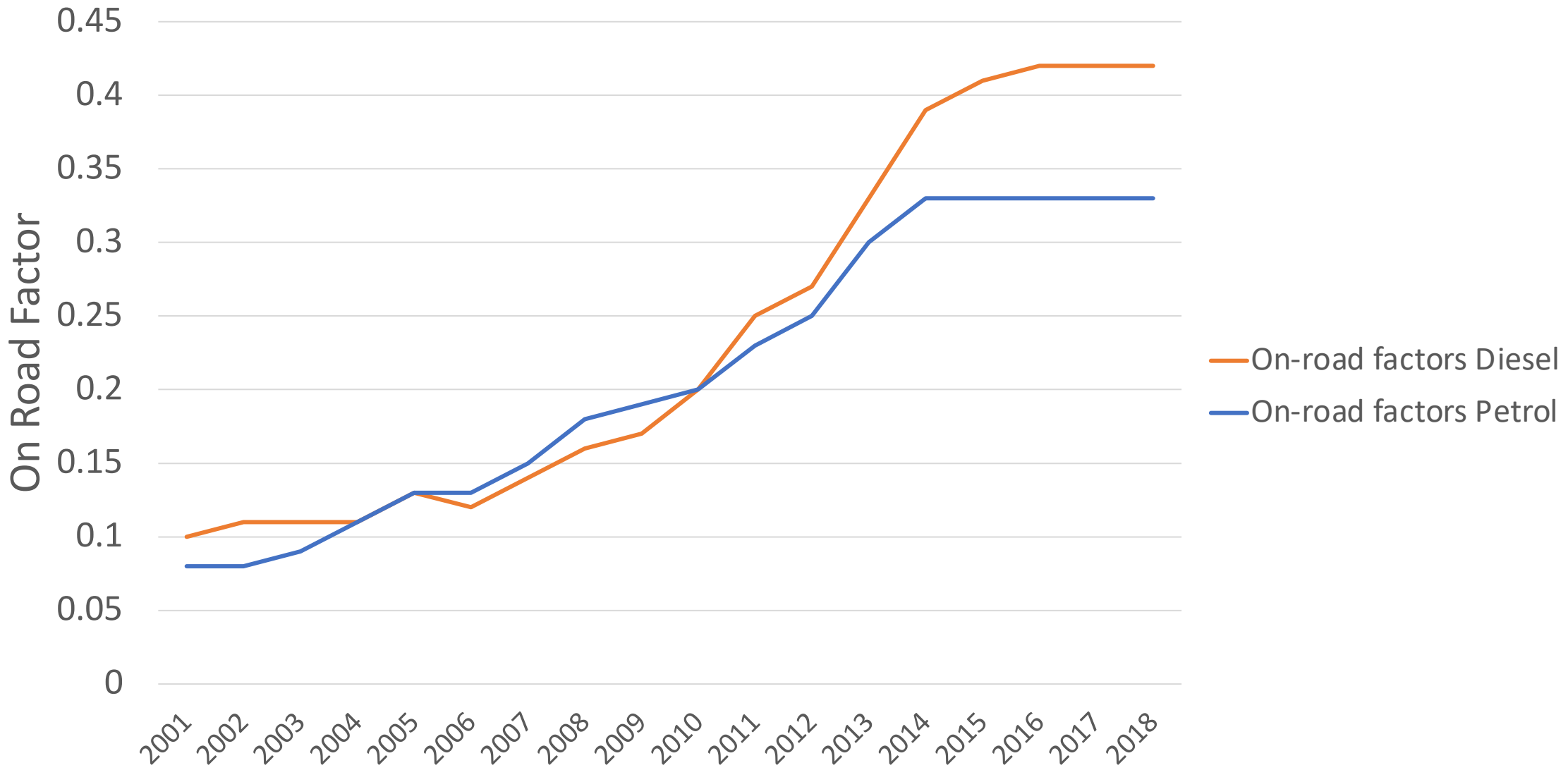
# Technology stock modelling



# *On-road factor (ORF)*

- ORF is the on-road factor which outlines the difference between the test values (or rated values) and actual, or on-road, fuel consumption
- It is a factor to account for the growing difference between manufacturer specified values under NEDC (New European Driving Cycle).
- Cars registered after 2018 will have their emissions bands specified under WLTP (World Harmonized Light Vehicle Test)
- WLTP utilises a profile deemed to be more similar to actual day-to-day usage than the previous NEDC standard

# *On-road factor (ORF)*



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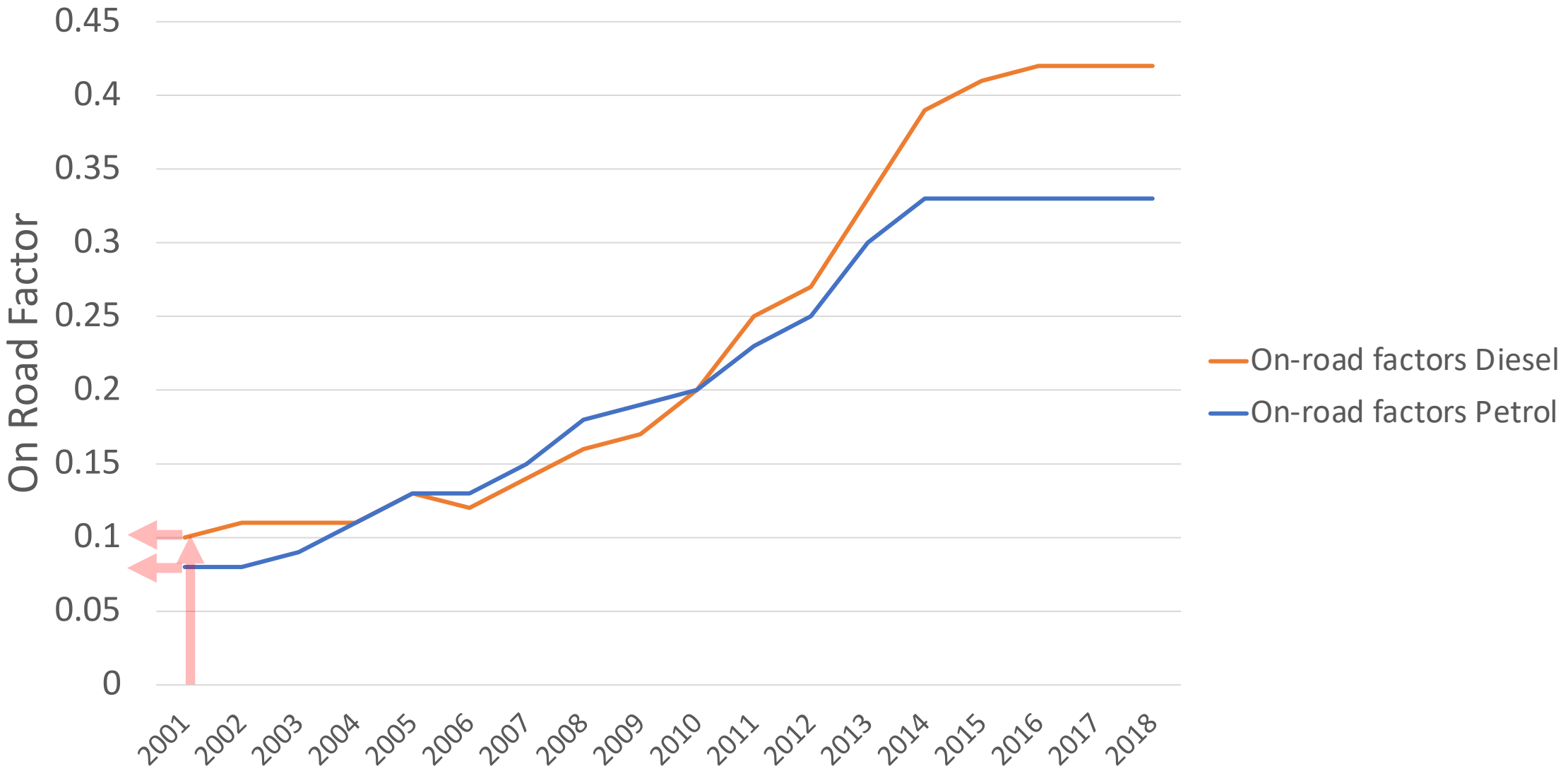

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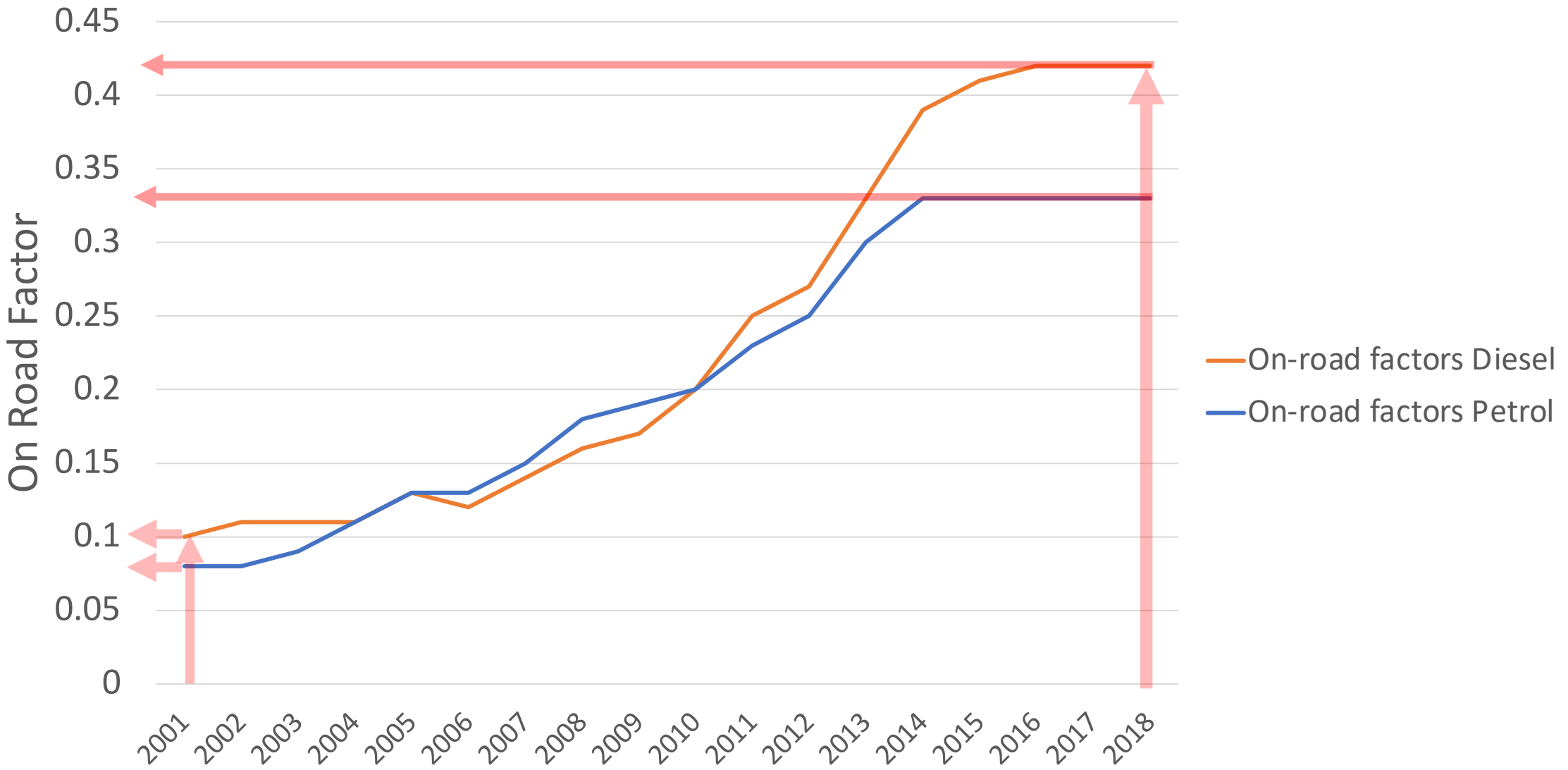
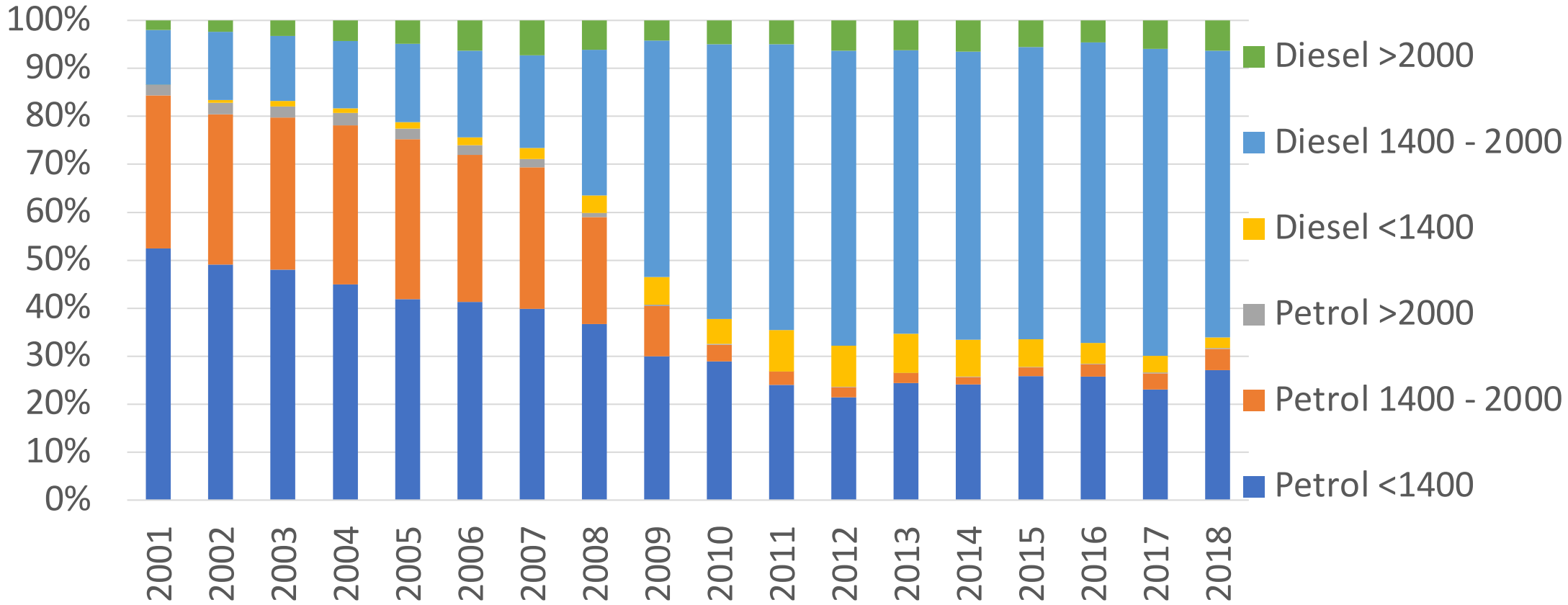


## *New car sales 2001 – 2018: Ireland*

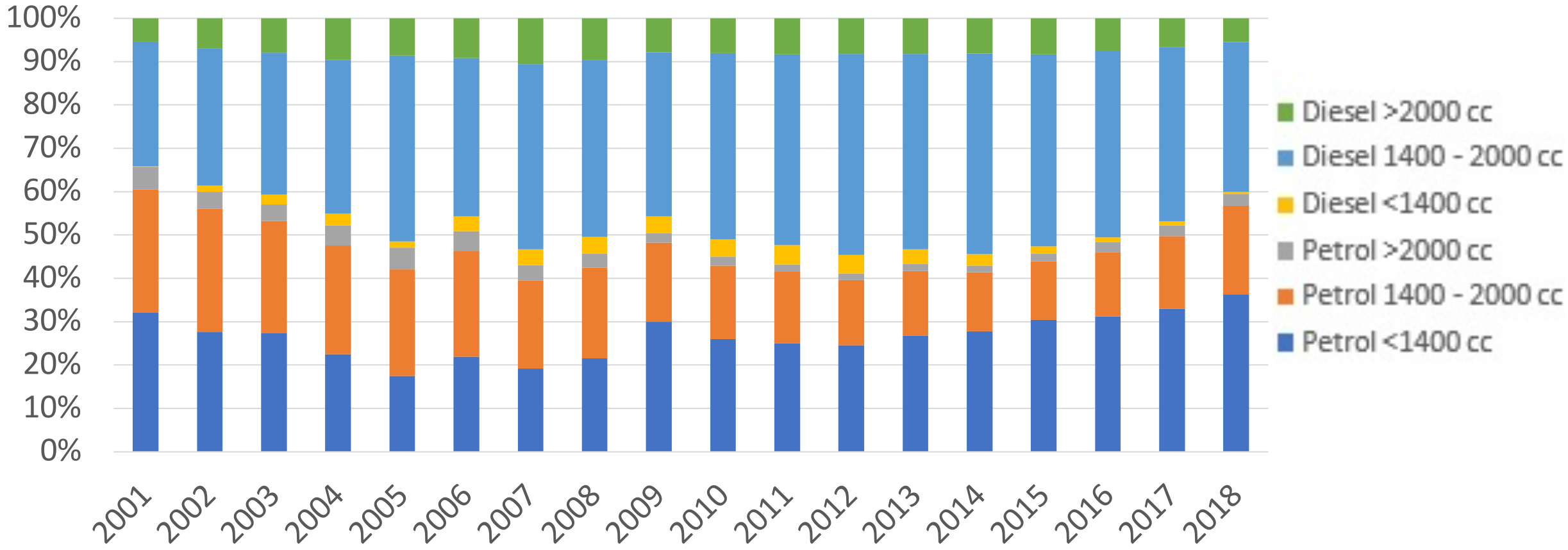
Below is the proportion of new car sales in Ireland by fuel type and engine size, as recorded by the Central Statistics Office [2]. This scenario provides the basis for the factual scenario for the Irish Car Stock Model, which uses the new car sales proportions from 2001 – 2018 as inputs.




[2] CSO, “Vehicles liscenced for the first time,” 2020. [Online]. Available: https://www.cso.ie/en/statistics/transport/vehicleslicensedforthefirsttime/.

## New car sales 2001 – 2018: EU wide

Figure 3. shows the proportion of new car sales in the EU by fuel type and engine size, as recorded by Eurostat [3]. The relationship between the EU figures and the Irish figures over the period of 2001 – 2008 is used to project a counterfactual scenario whereby the Irish car sales followed EU-wide trends in new technology sales.




[3] Eurostat, “Passenger Cars in the EU.” [Online]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php/Passenger_cars_in_the_EU. [Accessed: 05-Mar-2021].

## *Counterfactual new car sales, 2001 – 2018*

- The counter factual scenario reflects the pre-2008 trends in purchasing patterns in Ireland relative to the EU.
- Over the period of 2001 – 2008, regressions of market trends between Ireland and the EU of car share by fuel type and engine cc are examined.
- A simple regression analysis is adapted to project a counterfactual for the period of 2008 – 2018, with which to compare.

## *Counterfactual new car sales, 2001 – 2018*

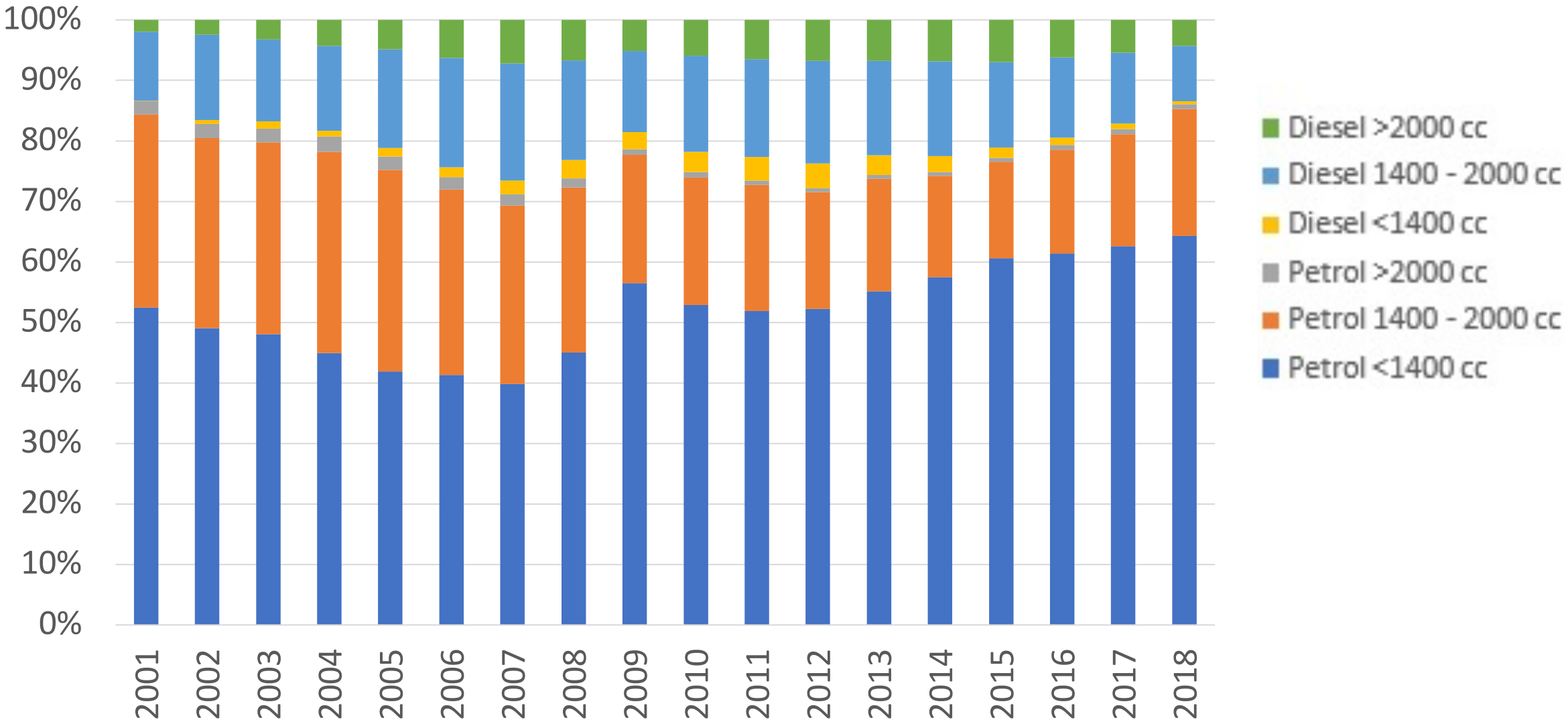
Determine the ordinary least squares regression with 3-year moving average of the changing sales proportion of the engine size and fuel type.

Calculate a projection of car sales by fuel type and engine cc for Irish cars based on EU-wide trends over the period of 2008 – 2018.

Calculate the total car stock by applying new car sales and historical survival rates of cars greater than 1 year in age.

Adjust of relative distance travelled by each car with respect to the behaviour of the factual scenario, to ensure that the vehicle kilometres serviced in the factual is the same as the counterfactual scenario.

# *Counterfactual proportion of new car sales in Ireland by fuel type and engine size*



## Fuel Consumption & CO2 emissions

$$Fuel\ Consumption = \frac{\text{Specific Energy Consumption} * (1 + \text{"on road" factor})}{100}$$

$$Energy\ Consumption\ (MJ/km) = Energy\ density\ (MJ/L) * Fuel\ consumption\ (L/km)$$

$$Emissions\ (TCO_2) = Energy\ density\ (TCO_2/MJ) * Energy\ Consumption\ (MJ)$$

## Stock Carbon Intensity

‘Stock carbon intensity’ is defined as the grams of carbon dioxide emitted for each kilometre driven by the Irish private passenger transport fleet.

It considers the variation in distance travelled by cars of different ages; fuel types and engine cc.  The stock carbon intensity is calculated from the distance travelled by cars and the total number of cars

$$Stock\ carbon\ intensity = \frac{Emissions}{Total\ distance}$$

## Annual motor tax revenue

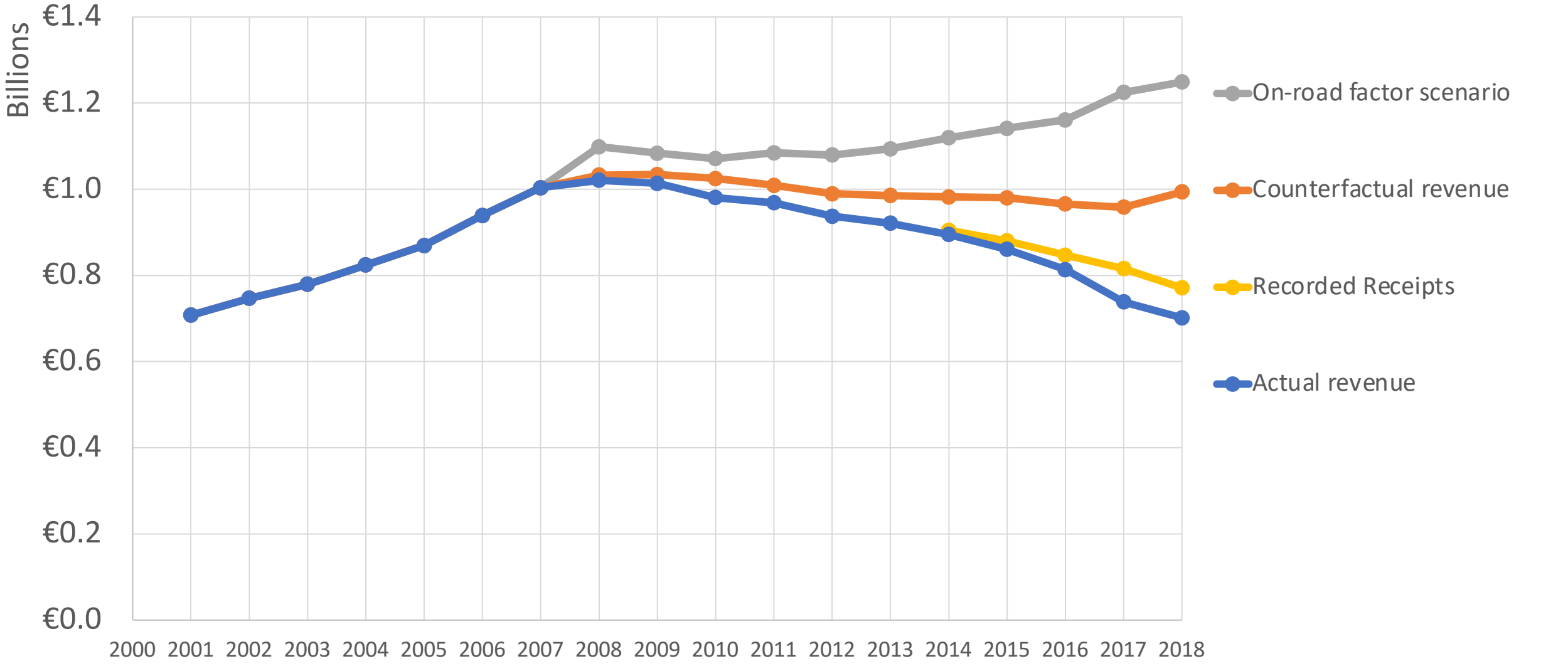
Tax revenue from cars registered before 2008 :

$$Revenue = Taxation\ rate_{engine\ cc} \times Number\ of\ vehicles_{engine\ cc,\ year}$$

For cars registered after 2008:

$$Revenue = Taxation\ rate_{emission\ band} \times Number\ of\ vehicles_{emission\ band,\ year}$$

# *Annual motor tax revenue*



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## #1:

- The 2008 car tax change influenced purchasing patterns. This change in purchasing patterns caused a slight shift in new car purchasing trends towards more efficient cars.

- For 2018, actual private car carbon dioxide emissions are calculated as **2.7% lower than in the counterfactual "no-tax change"** scenario case.

- There **is cumulative emissions savings over the 2008 - 2018 period** following the introduction of the tax change amounted to **1.6 MT of $CO_2$, when compared to the counterfactual**.

#2

- The average stock carbon intensity of the fleet reduced from **189 $gCO_2$/km in 2007** to **164 $gCO_2$/km in 2018**.

- The counterfactual scenario, which applied EU-wide trends to new sales in the Irish car stock, results in a carbon stock intensity of 168 gCO2/km in 2018.

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# #3

- **Recorded receipts from annual motor tax stood at €0.77 billion in 2018**.
- If on-road factors were accounted for, the tax payment revenue generated from the annual motor tax would be **€1.195 billion.**
- As for whether the policy was revenue neutral, it is estimated that annual motor tax receipts would have be €292 million higher in 2018 without the policy change.
- It also resulted in a tax-cut in disguise, as emission band tax rates were lower overall than their engine cc counterparts for most cars.

## Policy Recommendations

1. An adjustable approach to car taxation policy – to manage fluctuations in tax take – it could make sense to adjust the car tax every year

2. Gap between electric and low emission petrol/diesel still not great enough to incentivize a switch to EVs

3. Other EU states base vehicle taxes on power and weight – size is a problem also, embedded CO2 from vehicle production, parking and traffic

4. Absolute emissions from private vehicles rose over the period of 2008 – 2018, multi-faceted strategy needed to enable deep decarbonization of the passenger transport sector – modal shift and demand management

# Questions & suggestions welcome!
# Thanks for listening!


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# References

[1] H. Daly and B. P. Ó Gallachóir, “Modelling private car energy demand using a technological car stock model,” *Transp. Res. Part D Transp. Environ.*, 2011, doi: 10.1016/j.trd.2010.08.009
[2] CSO, “Vehicles liscenced for the first time,” 2020. [Online]. Available: https://www.cso.ie/en/statistics/transport/vehicleslicensedforthefirsttime/.
[3] Eurostat, “Passenger Cars in the EU.” [Online]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php/Passenger_cars_in_the_EU. [Accessed: 05-Mar-2021].

# Annual Motor Tax Scenarios

The revenue from Annual Motor Tax for the following scenarios were recorded:

1. **Recorded Receipts**: These are the documented revenues from the Parliamentary Budget Office [21].
2. **Actual recorded revenue:** This was the expected revenue over the period of 2001 – 2018, which applied the tax bands and the stock of cars as recorded in the Irish Car Stock Model. The calculations factor in the change in taxation for cars registered after 2008.
3. **Counterfactual revenue:** This is the revenue calculated based on the counterfactual car stock scenario as described in the methods section (Section 2.3). All cars in the stock have a motor tax based on the pre-2008 engine cc-based rates as documented in Appendix D.
4. **On-road factor revenue:** This is the revenue calculated based on tax charged based on the "on-road" emissions performance instead of the manufacturer specified $CO_2$ emissions over the period of 2008 – 2018. The calculations factor in the change in taxation from cars registered after 2008, with the engine cc-based rate applied to pre-2008 cars and the emissions band calculate rate applied to cars registered after 2008.

I know there was a previous suggestion to change the 'actual' to baseline but I think it is clearer to have the 'actual' as the baseline definition might be confusing for people without modelling background

| | Overall car fleet emissions | | Impact of the increasing on-road factors | | Stock carbon intensity | |
|---|---|---|---|---|---|---|
| Year | Actual Emissions | Counterfactual Emissions | Emissions with on-road factors | Emissions without without on-road factors | Actual stock carbon intensity | Counterfactual stock carbon intensity |
| | $MTCO_2$ | $MTCO_2$ | $MTCO_2$ | $MTCO_2$ | $gCO_2/km$ | $gCO_2/km$ |
| 2001 | 4.7 | 4.7 | 4.7 | 4.7 | 188.54 | 188.54 |
| 2002 | 4.9 | 4.9 | 4.9 | 4.9 | 188.75 | 188.75 |
| 2003 | 5.1 | 5.1 | 5.1 | 5.1 | 188.62 | 188.62 |
| 2004 | 5.3 | 5.3 | 5.3 | 5.3 | 188.86 | 188.86 |
| 2005 | 5.4 | 5.4 | 5.4 | 5.4 | 188.18 | 188.18 |
| 2006 | 5.8 | 5.8 | 5.8 | 5.8 | 188.66 | 188.66 |
| 2007 | 6.2 | 6.2 | 6.2 | 6.2 | 188.67 | 188.67 |
| 2008 | 5.7 | 5.8 | 5.7 | 5.7 | 186.13 | 187.11 |
| 2009 | 6.1 | 6.1 | 6.1 | 6.1 | 184.63 | 186.25 |
| 2010 | 5.6 | 5.7 | 5.6 | 5.6 | 178.73 | 181.72 |
| 2011 | 5.5 | 5.6 | 5.5 | 5.5 | 174.35 | 178.32 |
| 2012 | 5.1 | 5.2 | 5.1 | 5.1 | 172.99 | 178.10 |
| 2013 | 5.4 | 5.6 | 5.4 | 5.4 | 171.44 | 176.45 |
| 2014 | 5.5 | 5.7 | 5.5 | 5.4 | 169.88 | 175.94 |
| 2015 | 5.8 | 6.0 | 5.8 | 5.7 | 168.45 | 174.37 |
| 2016 | 6.0 | 6.2 | 6.0 | 5.9 | 167.38 | 173.32 |
| 2017 | 6.1 | 6.3 | 6.1 | 5.9 | 163.41 | 169.56 |
| 2018 | 5.8 | 6.0 | 5.8 | 5.6 | 163.67 | 168.24 |