

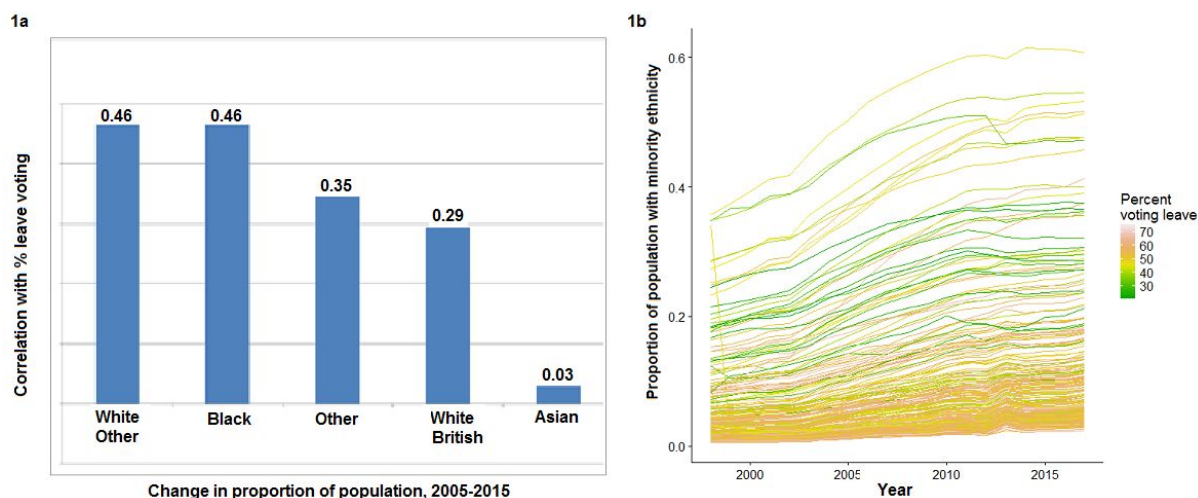
## Rapid change in ethnic composition- part of a wider Brexit picture?

Correlations have been reported by The Economist between a 13 year rate of change in the proportion of foreign born individuals in UK local areas and voting in the 2016 European referendum. Using regression and principal components analysis, we confirm the significance of rate of change in ethnic diversity, driven by a change in White British, White Other and Black populations. This varied by region, and the time window used for comparison also significantly impacts model results. Superficial correlations between change in Asian and Black populations and 'leave' voting were eliminated by including model variables linked to urban living. Age composition, turnout and population density all had smaller effect sizes than changes in ethnic composition.

### **Did rate of local change in ethnic composition influence Brexit voting?**

We tested The Economist's findings using independent data from The Consumer Data Research Centre (CDRC), which we linked to the 2015 Indices of Multiple Deprivation (IMD, [www.gov.uk](http://www.gov.uk)), and migration by year and 2016 population density data (The Office of National Statistics, ONS). Mean LSOA data were aggregated to the local area (LA) level. Considering proportions of 'leave' votes per LA as an output, there was a 0.88 correlation between the CDRC predicted non-White British population for 2005 and the ONS non-UK born figures used by The Economist. Low superficial correlations were visualised between change within all ethnic groups and leave/remain voting (Fig. 1a). Voters in regions with higher proportions of ethnic minorities were more likely to vote 'leave' if their area's ethnic composition had dramatically changed over the past 5 to 15 years (Fig. 1b).

**Fig.1.** Correlations between 'leave' votes and **a)** change in ethnicity proportion in population (2005-2015); **b)** mean change in representation of ethnic minorities by area.



To assess the fit of linear models restricted to ethnicity data, summarising ethnicities ('Asian', 'Black', 'White British', 'White Other', 'Other'), we fitted an ordinary least squares model with proportion of 'remain' votes as a dependent variable. Completing iterations for all possible combinations of start/end year, we included as explanatory variables change in population of each ethnic group from 1998-2015 normalised to either start or end population, 2015 White British population, and IMD decile (England only). Best fitting models for the UK and England restricted to these variables explained 62% and 55% of variation in voting, implying other variables not considered were likely to have been significant.

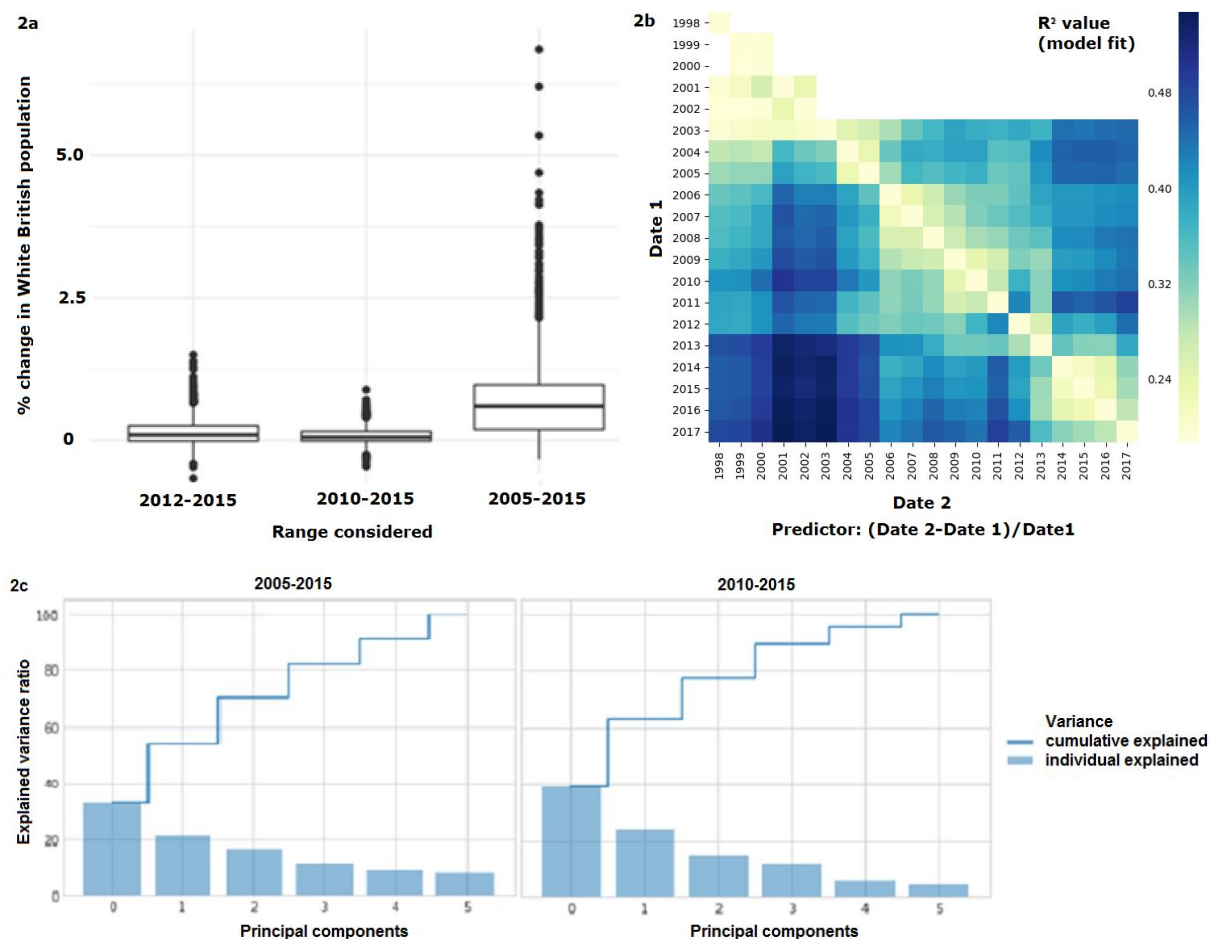
In a further, expanded linear model, we considered change in proportion of ethnicities by area from 2005-2015 with other explanatory variables; age composition (18+ in 15 yr bins, 65+), population density (people/km<sup>2</sup>), area size (km<sup>2</sup>), proportion of ballots rejected and mid-2016 population estimate, with proportion of 'leave' votes as an outcome. We simplified this on a stepwise basis (code at [https://github.com/RUMgroup/brexit\\_data\\_challenge](https://github.com/RUMgroup/brexit_data_challenge)). Areas showing high rates of change in their White British population were more likely to vote 'leave' (P=0.009), as were those with high rates of

change in their Black population ( $P=3.55e^{-06}$ ). Contrary to expectations, areas with more people aged 65+ were less likely to vote 'leave' ( $P=0.005$ ), as were areas with more people aged 18-24 ( $P<2e^{-16}$ ), and 35-44 ( $P=4.41e^{-10}$ ). Leave votes were more likely if areas had undergone high proportional change in their non-British white population from 2005-2015 ( $P=0.009$ ). Larger local authorities ( $P=8.43e^{-12}$ ), those with higher population density ( $2.19e^{-11}$ ), higher voter turnout ( $P=2.63e^{-08}$ ), and with more ballots rejected ( $P=6.83e^{-07}$ ), which may represent urban areas and high proportions of non native English speakers, were all more likely to vote 'remain'. Scaling the model coefficients indicated change in the proportions of Black ethnicity and White Other ethnicity as having the largest effect sizes.

## Study window range significantly impacts findings

The Economist considered change in migration rate over a 13 year period, yet voting may have been led by more recent experiences. From 1998-2015, there were significant differences in ethnic composition change by local authority ( $p<0.001$ ,  $F\text{-value}=989.2$ ,  $df=2$ ), and by varying time range. The relationship between ethnicity and time span is non-linear; mean change in White British ethnicity frequency was higher and more varied by area from 2012-2015 than from 2010-2015 (Fig.2a). Our least squares model was sensitive to time window used and normalising either to start or end value, with end value being preferable. Change in ethnic composition over longer time spans best explained voting (Fig. 2b), and PCA demonstrated higher explained variation over 10 years than over 5 years (Fig. 2c).

**Fig.2.** Comparison of **a)** % change in White British population composition over varying time ranges; **b)** model fit ( $R^2$ ) across varied start and end year pairings



Our analysis supports rates of change in ethnic composition over time predicting referendum voting, specifically for White British, Black and White Other populations. However, other significant variables must be taken into account to understand voter motivation, which were lacking in the original Economist study. Study time window and method of normalisation impact model fit, and should be carefully considered in analyses of this type.