Dissertation draft

Tobias Leigh-Wood

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Contents

Standard economic theory suggests that retirement annuities, which provide a guaranteed income stream until the end of life, should be highly valued by individuals as a way to insure against late death Yaari (1965). However, in developed countries, rates of annuitisation are far below the levels that theory predicts. The literature has suggested several reasons for this, but there is no consensus about which mechanism is dominant. I exploit early retirees' consumption responses to a reform to annuity policy in the UK to add to this literature. [**Add something once I have a conclusion**].

In the UK, adults have three methods of funding retirement: the state pension; defined benefit (DB) employee pension schemes, which provide an income in retirement based on years of service and a function of wages; and defined contribution (DC) pensions, in which individuals save and invest in a tax-advantaged account that is usually supplemented with employer contributions. Under the 2010-2015 coalition government in the UK, the law regarding the use of private DC pensions at retirement changed. Individuals were no longer forced to annuitise, which provides a constant income until death, their pension pots and could access them in a variety of ways such as a lump sum withdrawal or income drawdown, which is a steady withdrawal of assets with the remainder left in the pot - common advice is to take 4% a year. Subsequently the number of annuities sold in the UK dropped precipitously.

In this paper, I first use the policy reform as a discontinuity to measure the impact of forced annuitisation on the consumption levels of individuals in the first few years of retirement. Given that the reform was implemented suddenly and without advanced notice before the Spring 2014 budget, I claim that individuals who retired in 2015, 2016 or 2017 are otherwise similar to those who retired year in 2011, 2012 and 2013 except for the fact the later retirees do not need to annuitise their DC pension pots. Therefore, I can use a regression discontinuity to identify the effect that forced annuitisation has on the consumption of retirees.

I then test two competing hypotheses for the annuity puzzle: bequests and pessimistic life expectancy. The annuity puzzle was first identified by Yaari (1965) and is a classed as a problem since standard economic theory cannot explain the lack of annuitisation that is observed in the real world. Two possible explanations are bequests and life expectancy: individuals want to leave an estate for their heirs to inherit and they cannot do this if they annuitise their wealth; or individuals may believe they will not live as long as annuity providers think they will and therefore annuities that are on the market do not appear to be good value. Depending on which reason explains the lack of annuitisation in the UK, the consumption response of retirees to the pension reform will differ. If individuals do not annuitise because of pessimistic life expectancy their consumption should increase after the reform. If, on the other hand, individuals do not annuitise because of a bequest motive, consumption should not change much as a result of the reform.

I will solve lifecycle models (**maybe add something about lifecycle models here**) for both of these cases and simulate consumption decisions with and without forced annuitisation. I will then use a variety of empirical models to measure the consumption change in early retirement that resulted from the policy reform. The sign and magnitude of this change will be indicative of the mechanism causing the annuitisation problem.

The importance of retirement policy to individuals in the UK is growing. The number of individuals of pensionable age is expected to increase from 11.9 million in 2020 to 15.2 million in 2045 according to the latest Office for National Statistics (ONS) and for every 1000 people of working age there will be 341 of pensionable age in 2045 compared to 280 in 2020 ONS (2020). The increase in absolute and relative numbers of elderly people makes retirement policy more consequential. Moreover, private DC pensions are becoming increasingly common and are predicted to grow as current cohorts age Cribb and Karjalainen (2023). Therefore, policies regarding how private pensions can be accessed will have a larger impact on overall welfare for retirees.

Moreover, understanding how retirees spend their money over retirement is an important policy question of its own. If retirees spend too much in early retirement, the state may need to provide for them towards the end of their lives. This has implications for government budgets, especially since population aging means more individuals will require expensive end of life care. On the other hand, if retirees over-save and do not spend, the economy may face a dynamic inefficiency whereby consumption per capita could be increased if savings were decreased. (Get dynamic inefficiency reference.)

0.1 Literature review

My paper builds on three main strands of literature: that of the annuity puzzle, exploring reasons that some retirees choose not to annuitise; the retirement saving puzzle, looking at consumption and saving behaviour over retirement; and lifecycle models, whereby the above problems are explained using a tractable model of human decision making.

Yaari (1965) was the first to show that under standard assumptions we would expect individuals to annuitise all of their wealth at retirement to insure against the risk of long life. Since then there has been much literature discussing possible reasons that people do not annuitise. Finkelstein and Poterba (2002) and Finkelstein and Poterba (2004) find evidence of adverse selection, thereby making the 'money's worth' of annuities lower for the general population as opposed to the population of annuitants. However, they also find that theory would still predict annuitisation.

Friedman and Warshawsky (1990) show that annuitisation decisions can be fully explained by a mixture of bequest motives and actuarily unfair annuities. They solve an augmented life-cycle model with a range of parameters on how severe the rate of return is on the annuity versus market rates. For plausible values they find that individuals would optimally not annuitise much wealth. Similarly to Finkelstein and Poterba (2004), Friedman and Warshawsky (1988) show that there is a significant difference between the life expectancy of annuitants and the general population in the American annuity market but this cannot fully explain the annuitisation puzzle. Only when bequest motives are added to the model can annuitisation rates be rationalized.

Lockwood (2012) builds on this and shows that a realistic bequest motive in lifecycle simulations achieves realistic annuitisation rates. He solves a simple lifecycle model with bequest motives taken from several recent papers in the literature. The bequest motives he picks therefore match other important aspects of the lifecycle model such as how much individuals actually bequest and how rich individuals are when they bequest.

Lockwood (2018)

Vidal-Melia and Lejárraga-García (2004) have some interesting results. Need to talk about that.

If I add 300 more words here then I will be at 5000!

There are some more papers I will include here.

1 Data and Policy reform

1.1 Data

The main data set I use is the English Longitudinal Study of Ageing (ELSA) Banks et al. (2023). ELSA picks individuals over the age of 50 to survey every two years until death. If individuals leave the survey ELSA replaces them so that it is representative of the over 50 population in the UK. Individuals are asked a range of questions relating to their income and wealth as well as expectations about the future. One benefit of using ELSA is that it includes data on pension types for individuals who are working. Therefore, I can differentiate between individuals who have a DC pension and those who have a DB pension. There have been 9 waves of ELSA data collection, the first was in 2001 and collections happened every two years thereafter.

Importantly ELSA also includes information on pension size that the Institute for Fiscal Studies (IFS) calculated, this is only available up until wave 5 (which was collected in 2010 and 2011) at which point I use a real return of 3% to predict forward the pension wealth variable until retirement. ELSA also includes a measure of all non-housing financial wealth which I use in some specifications because of these issues with pension wealth. Due to slight differences in the ELSA questions between years, I use 'Harmonized ELSA' [1] which

[1]This analysis uses data or information from the Harmonized ELSA dataset and Codebook, Version

ensures that variables are comparable across waves. Since this only includes a subset of the questions in ELSA, I also supplement it with variables taken directly from the data such as questions that deal with life expectancy.

ELSA also includes questions on expenditures. In particular, individuals are asked how much they consume across a range of broad categories including in-house food consumption, out-of-house food consumption, leisure consumption, clothes consumption and consumption on utility bills and rent. I use also use two variables related to life expectancy that I discuss in more detail below.

I also use 'life tables' from the UK's ONS. These provide me with risk of death for each age group. I adjust them to make death certain at age 110 as is common in the literature. I transform these so that I have risk of death conditional on being a given age since this is what I use in the life cycle simulations. I also use these objective probabilities to calculate annuity prices for individuals.

To illustrate the effect the reform had on sales of annuities in the UK I obtained product data from the Financial Conduct Authority. These track the sales of different financial products overtime including data annuities.

Life expectancy impacts decision to retire for two reasons. Firstly, it directly impacts the price that an annuity will cost for individuals. Older individuals and those with pre-existing health conditions generally can buy an annuity that provides a greater income stream than individuals who are younger. Secondly, private information about life expectancy impacts the perceived value of an annuity. If an individual expects to outlive the general population an annuity, at a given price, will appear a much better deal to them. Likewise, an individuals life expectancy will change their decision on how to consume and save through retirement.

To calculate subjective life expectancies I follow O'Dea and Sturrock (2023). Individuals are asked "What are the chances that you will live to be age X or more?" where X changes depending on the age of the interviewee. If individuals were under 65 then X was 75, if individuals were 66 and older they were asked the age that was 11 to 15 years older than them and is a multiple of 5. From wave three respondents were also asked "What are the chances that you will live to be age 85 or more?" if they were under 70. As most recent retirees are under 70 we therefore have two data points. I first drop from the data individuals who think it is more likely that they reach a higher age than a younger age since this shows a misunderstanding of the question. I then add as a third data point their objective chance of reaching 110 according to the ONS life tables. I fit these three

G.2 as of July 2021 developed by the Gateway to Global Aging Data. The development of the Harmonized ELSA was funded by the National Institute on Aging (R01 AG030153, RC2 AG036619, R03 AG043052). For more information, please refer to https://g2aging.org/.

points to a Weibull distribution, which is commonly used by demographers to estimate how populations will age, using non-linear least squares. Then I create subjective survival tables using parameters from the Weibull distribution.

I could go into more detail here? Maybe I should. Add equation etc

1.2 Policy reform

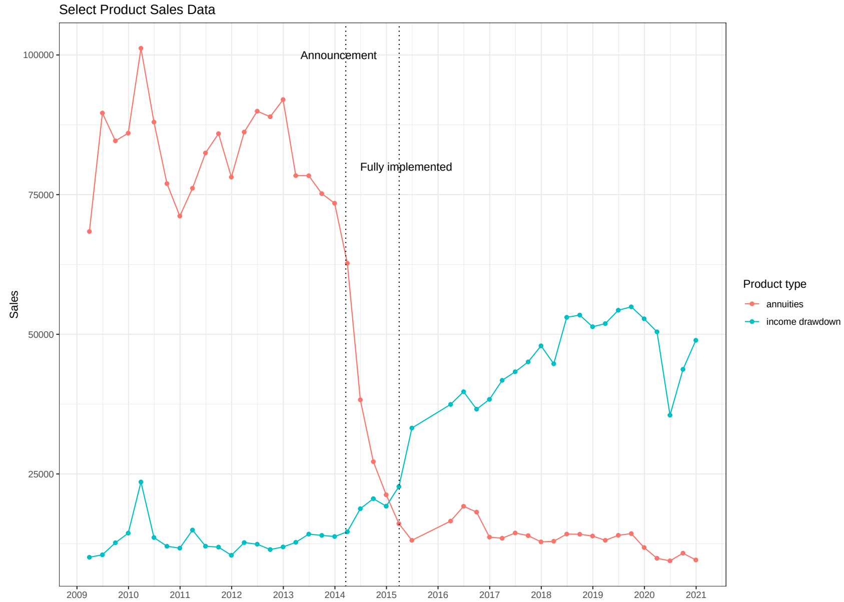
Successive governments in the UK have attempted to reform both the public and private pension system. Prior to 1987, participation in private schemes was limited to employees of firms that had offered them, and there were few alternatives to the public state pension or defined benefit scheme that a public sector employer would offer. From 1989, individuals in the UK were allowed to open tax advantaged self-invested personal pensions alongside any pension their employer offered. The 2004 Finance Act rationalised taxation rates on different types of pensions. But DC pension pots could still only be used to buy an annuity after taking out a maximum of 25% as a tax free lump sum withdrawal from age 55 onwards. Most pension pots also required that individuals access them before age 75.

Announced in the spring budget of 2014, the so called 'pensions freedom act' received Royal Asset in December 2014 marked the end of a series of pension reforms carried out by the coalition government between 2010 and 2015. The reform made it possible to withdraw the first 25% from a pension pot tax free and the rest subject to the marginal rate of income tax that an individual faced. In the June 2010 budget, the government made a first reform to the annuitisation rules, creating a minimum income requirement above which individuals would not need to annuitise more HMT (2011) (this meant high income retirees would not need to annuitise their wealth). However, this was set at £20,000 and therefore few individuals were eligible. The minimum income requirement was scrapped in the 2014 bill, finally eliminating the compulsory annuities market, with one government minister saying pension pots 'can be used to buy Lamborghinis' Watt and Elliott (2014).

The impact of the reforms on annuity demand has been documented by Cannon et al. (2016). Using data from the Association of British Insurers, they show that annuity demand dropped by 75% from its maximum in 2011 **Check** . Figure 1 shows purchases of annuities overtime and demonstrates the sharp decrease in purchases that happened from 2014 to 2015. There was an increase in the number of pensions that were being accessed using an income drawdown product, but these do not fully account for the drop in annuitisation.

Figure 2 shows the distribution of how pension pots were first accessed at retirement in 2021-22. In 2021, 196,736 pots were fully withdrawn at retirement, accounting for over

Figure 1: Pension pots accessed



50% of pots. Prior to the policy reform this was not the case – most defined contribution pensions were accessed through annuities.

Also of specific interest to the annuity market was the European Union's 'Equal Treatment in Goods and Services Directive' of 2004. This prohibited discrimination in the provision and cost of goods and services based on sex. Up until 2011, there was a clause that stated insurers were allowed to charge different premiums if it was based on evidence that sex is correlated with different amounts of risk. However, in March 2011, the European Court of Justice ruled that insurers were not allowed to charge different amounts and gave them until December 2012 to implement the ruling. This change meant that annuity products could no longer be priced differently for men and women in the UK. However, given that this change was implemented two years before the pension freedoms act, I can still identify the impact of the pensions freedom act on early retirement consumption.

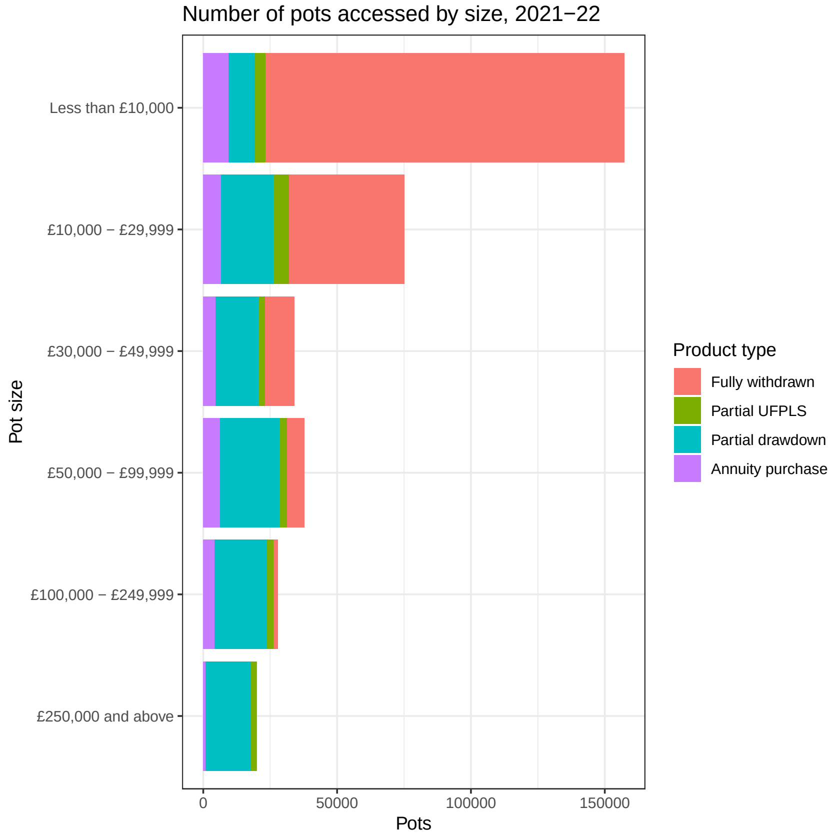
1.3 Covariate Balance

Table 1 shows various summary statistics for each variable of interest from ELSA and the ONS.

As required, retirement year is between 2011 and 2013 for the control group and 2015 and

[2]Partial UFPLS (uncrystallised funds pension lump sum) is similar to Partial drawdown but with a different tax schedule. With partial drawdown you take the whole 25% tax free amount at once whereas with UFPLS you only claim the 25% on the amount you are taking out. This option is better if you may want to buy another retirement product in the future such as an annuity.

Figure 2: How pension pots are accessed[2]



2017 for the treatment group. However, as discussed above their interview date is after or the same as the retirement year because we are tracking consumption in retirement.

The second retirement group, those who retired post reform, is small with just 728 non missing observations for gender as opposed to 941 individuals in the control group. The control group are more female, retired at a slightly younger age and expected to retire slightly earlier. This could be because this period was affected by the increase in the state pension age for women from age 60 in 2010 to age 65 in 2018. Since this change happened gradually and occured over the whole period I do not expect it to influence the results. The DifferenceAge row tracks the difference between expected and actual pension age.

The treatment group has higher financial wealth with a median of £66,000 at time of interview as opposed to £55,000 in the control group. Likewise, the second group are more likely to have held a DC pension at some point and have much more money in them. Both groups are equally likely to have a defined benefit pension with roughly 44% of individuals across both samples having a defined benefit pension. In general, DB pensions are more prevalent than DC pensions in the data, this reflects the same trend that is observed in population of UK retiree. Home ownership is roughly equal across groups although the second group have slightly higher housing wealth. **I have not inflation adjusted but I am thinking about it?**

Both groups are similarly long-lived according when using ONS life tables to calculate life expectancy based on gender, age and the year the interview was carried out in. Subjective life expectancies are also similar across groups, with individuals expecting to live another 21 years as opposed to the 24 that the ONS would expect them to live. **Maybe add in prob of survival to age 85 or 90 or something Also add in an indicator for living alone or living with someone else**

Unfortunately, some consumption data is missing for some individuals. The food categories have the least missing data and the leisure consumption category has the most missing data.

Check why total consumption adds up to so much more than all the categories added together? Do they include rent and housing in consumption?

Overall, the groups appear to have slightly different wealth profiles with the treatment group being richer and slightly more likely to have DC pension wealth. On key demographic characteristics, however, the groups are similar, the difference in retirement age between the two groups can be mostly explained by the difference in expected retirement age meaning that individuals have not en masse decided to delay retirement and avoid annuitisation.

Table 1: Summary statistics

	Max		Mean		Median		Min		Non Missing		
	Control	Treat	Control	Treat	Control	Treat	Control	Treat	Control	Treat	Control
Gender	1.0	1.0	0.455	0.493	0.0	0.0	0.0	0.0	941	728	0.498
RetirementYear	2013.0	2017.0	2011.878	2015.865	2012.0	2016.0	2011.0	2015.0	941	728	0.763
InterviewYear	2016.0	2019.0	2013.306	2017.357	2014.0	2017.0	2011.0	2015.0	941	728	1.188
YearsSinceRetirement	2.0	2.0	1.040	0.999	1.0	1.0	0.0	0.0	941	728	0.738
RetiredAge	82.0	81.0	62.918	63.750	63.0	64.0	47.0	50.0	941	728	4.441
AgeAtInterview	83.0	82.0	63.959	64.749	64.0	65.0	49.0	51.0	941	728	4.467
ExpectedRetiredAge	120.0	120.0	62.282	62.639	60.0	60.0	54.0	50.0	724	609	5.320
DifferenceAge	48.0	57.0	-0.682	-1.205	-1.0	-1.0	-8.0	-22.0	724	609	4.423
FinancialWealth (thousands)	1910.5	2890.0	120.487	167.023	54.9	65.6	-77.0	-33.0	912	721	210.588
DCPension	1.0	1.0	0.197	0.257	0.0	0.0	0.0	0.0	941	728	0.398
DCValue (thousands)	8171.7	18367.9	73.920	128.958	0.0	0.0	0.0	0.0	832	598	462.933
DBPension	1.0	1.0	0.438	0.434	0.0	0.0	0.0	0.0	941	728	0.496
StatePension	19.1	27.6	4.576	4.774	5.8	6.1	0.0	0.0	934	724	3.990
OwnsHouse	1.0	1.0	0.872	0.890	1.0	1.0	0.0	0.0	938	727	0.334
HouseValue (thousands)	1300.0	3000.0	232.313	310.218	200.0	260.0	0.0	-143.0	941	728	181.210
ObjectiveLifeExp	38.0	38.6	23.840	23.721	23.9	23.4	7.9	8.8	941	728	4.472
SubjectiveLifeExp	36.6	37.9	20.902	21.129	21.2	21.3	4.6	4.1	638	463	6.411
TotalConsump	435526.0	4602.3	2427.470	796.235	648.8	702.8	130.2	136.9	768	304	27132.273
FoodConsump	1938.1	2738.1	414.373	439.469	362.4	397.4	31.7	36.1	929	714	237.020
FoodConsumpIn	440.0	400.0	80.059	80.884	70.0	70.0	1.0	1.0	930	714	48.230
FoodConsumpOut	750.0	1500.0	66.550	88.406	50.0	50.0	0.0	0.0	937	722	78.103
ClothingConsump	1450.0	2000.0	87.642	83.045	40.0	40.0	0.0	0.0	825	332	135.286
LeisureConsump	530.0	150.0	84.940	75.000	60.0	75.0	0.0	0.0	744	2	86.702
UtilityConsump	483.1	580.9	108.034	112.850	96.0	100.0	0.0	0.0	785	308	59.960

As a further test for balance I regress demographic and financial characteristics of individuals on year of birth and the treatment dummy. We can then see if the treatment groups differ on key characteristics such as financial wealth or retirement age. For a regression discontinuity to be valid we need the treatment and control groups to be similar along all other characteristics apart from the treatment variable.

In particular I run:

$$Y_i = \alpha + \beta Post_i + \gamma YOB_i + \kappa(Post_i \times YOB_i) + \epsilon_i$$

Table 2 shows these results. We can see that being in the treatment group. **I am still thinking about this.**

One threat to validity is manipulation of the running variable – which is the variable that decides whether an individual is in the treatment group or not – in our case retirement year. This is probably quite a threat in this setting as individuals could delay retirement and/or the purchase of an annuity until after the reform. To check whether this is happening we see whether the difference between real retirement age and the first expected retirement age recorded in the data are different for those retiring before 2014 compared to those retiring after 2014. As shown above in Table 1 this not the case.

However, it is possible that individuals do not buy an annuity at the time of retirement since the law prior to 2014 only required that they access the pot by age 75. They may decide to keep their DC pension untouched and live off other income and assets before accessing it later. Since we do not have data on the exact purchase date of annuities we cannot track whether annuity purchases were delayed because of this. However, there is relatively stable annuity demand before the policy reform. If individuals delayed annuity purchases in expectation of the reform we would observe declines in purchases before the reform was announced.

2 Empirical models

In this section I outline the key empirical models I run with both the simulated consumption data from the lifecycle models and with the real data from ELSA. I then see which lifecycle model better fits the consumption response that occurred as a result of the pension reform.

I use a regression discontinuity design for which I compare the consumption of early retirees after the policy reform to that of people who retired just before the policy reform. The key assumption implicit in regression discontinuities is that nothing else changes at the time of the jump apart from the policy of interest, and that the policy occurs without individuals predicting it and altering their behaviour. As I have argued above,

Table 2: Covariate Balance

	Pt. est.	SE
Gender	2.243	10.468
RetirementYear	-12.528	16.127
InterviewYear	-11.243	24.959
YearsSinceRetirement	9.716	16.056
RetiredAge	-12.528	16.127
AgeAtInterview	-2.811	22.725
ExpectedRetiredAge	-240.427	129.345
DifferenceAge	-246.763	128.979
FinancialWealth (thousands)	-4769.638	5410.054
DCPension	-13.608	8.933
DCValue (thousands)	-1978.144	20284.768
DBPension	7.974	10.386
StatePension	67.008	71.043
OwnsHouse	-0.697	6.968
HouseValue (thousands)	6630.186	4775.236
ObjectiveLifeExp	13.086	30.559
SubjectiveLifeExp	0.351	182.705

the demographic information in the data suggest that individuals did not delay retirement and that there was no delay in annuitisation as shown by the quick and sudden decline in annuity purchases. Moreover, anecdotal evidence from media and business sources at the time of the announcement show that there was surprise the government had gone this far, with money marketing describing the change as a "bombshell" Selby (2014).

Retirement year is the running variable and individuals are treated if retirement year is greater than 2014 and less than or equal to 2017. I use consumption data of individuals up to 2 years into retirement so that the sample size is larger. So if someone retired in 2015 and had consumption data in 2015 and 2017, I include both values. An individual is considered not treated if they retire before 2013 and after 2011. To account for the fact that the reform only impacted individuals who had accumulated defined contribution pension pots I interact the treatment dummy with an indicator variable signalling whether the individual had ever held a DC pension pot.

Because of the differences in financial characteristics between the groups, I add controls for financial wealth, housing wealth and whether an individual owns their own home.

$$Cons_{it} = \gamma X_{it} + \beta PostReform_{it} + \epsilon$$

And X_{it} is a set of controls.

Table 3: DC Only

	TotalConsump	FoodConsump	FoodConsumpIn	FoodConsumpOut	ClothingConsump
(Intercept)	1347.136	580.816	79.234	220.237	40.813
	(744.626)	(347.941)	(69.250)	(122.426)	(218.065)
PostReform	73.892	3.254	−1.374	11.117	26.921
	(67.157)	(26.366)	(5.223)	(9.016)	(23.977)
RetiredAge	−4.649	−3.297	−0.101	−2.584	−0.292
	(10.437)	(5.460)	(1.096)	(1.889)	(3.614)
FinancialWealth (thousands)	0.229	0.173	0.013	0.111	−0.012
	(0.114)	(0.050)	(0.010)	(0.025)	(0.052)
Gender	−19.635	−37.100	−7.336	−5.995	13.219
	(62.688)	(27.934)	(5.469)	(10.113)	(24.657)
DCValue (thousands)	−0.011	0.004	0.002	−0.004	−0.003
	(0.008)	(0.007)	(0.001)	(0.001)	(0.003)
YearsSinceRetirement	−1.663	−7.382	−0.148	−7.745	6.264
	(43.909)	(16.742)	(3.220)	(6.173)	(14.367)
OwnsHouse	−261.372	102.718	21.363	10.643	73.742
	(195.477)	(37.853)	(7.286)	(14.801)	(16.508)
StatePension	−14.029	−3.772	−1.176	1.255	−3.033
	(9.524)	(4.130)	(0.849)	(1.251)	(4.033)
Num.Obs.	209	326	326	330	221
R2	0.068	0.063	0.046	0.102	0.035
R2 Adj.	0.031	0.039	0.022	0.079	−0.002
AIC	3154.1	4499.9	3452.0	3834.7	2895.0
BIC	3187.6	4537.8	3489.9	3872.7	2929.0
Log.Lik.	−1567.067	−2239.962	−1716.008	−1907.357	−1437.512
RMSE	436.59	233.25	46.75	78.33	161.68
Std.Errors	HC3	HC3	HC3	HC3	HC3

Table 3 shows the results of this specification on the various consumption indicators. Column 1 has total monthly consumption on the left hand side of the regression equation. We can see that being in the treatment group is associated with £73 more a week in spending overall across all categories of expenditure. This is not statistically significant using robust standard errors **find a reference for the SE that I use**. Being further into retirement at the time of interview is also associated with lower consumption whilst those who retired later have lower consumption because years since the start of retirement is associated with higher total consumption.

Columns 2 through 4 use food consumption as the outcome variable. Interestingly, food consumption inside the house does not increase as a result of the policy reform but food consumed away from the house does increase. If individuals see their pension pot, that they previously could not access, as a shock to their wealth, like winning the lottery, then we would expect the consumption basket to include more goods that are perceived as luxuries. Inline with this, consumption on clothing, shown in column 4, increases as a result of the policy change.

One concern is that the group who retired after 2014 are just generally different to those who retired before and perhaps consume more outside the home anyway. The financial characteristic data presented in 1 would support this hypothesis. To test for these cohort effects I run a difference in difference regression to complement the regression discontinuity just shown. I add individuals who have a defined benefit pension pot into the model and interact the policy change with dummies for having different types of pension. Specifically I run:

$$Cons_{it} = \gamma X_{it} + \beta_1 PostReform_{it} + \beta_2 PostReform * DC_{it} + \beta_3 PostReform * DB_{it} + \epsilon$$

This makes the coefficient of interest β_2, which shows us the difference in the change in consumption between the DC only group and the base group that has neither a DB or DC pension. Since rules for DB pensions did not change under the pensions freedom act, those with a DB pension or no pension can be seen as a natural counterfactual group to judge the consumption of the DC group against.

Table 4: All individuals with interaction

	TotalConsump	FoodConsump	FoodConsumpIn	FoodConsumpOut	ClothingConsump
(Intercept)	33 095.382	280.618	54.774	38.276	124.084
	(23 150.398)	(119.930)	(23.383)	(42.972)	(59.760)
PostReform	−3890.590	33.145	2.292	23.126	−1.141
	(2464.169)	(19.144)	(3.812)	(6.217)	(12.746)
DCPension	−2490.386	36.882	5.797	11.024	−2.559
	(1518.925)	(21.384)	(4.425)	(6.613)	(9.972)
DBPension	−2865.789	25.441	1.328	19.703	24.950
	(1884.055)	(16.401)	(3.322)	(5.237)	(9.687)
RetiredAge	−301.132	0.292	0.138	−0.236	−1.602
	(268.224)	(1.915)	(0.374)	(0.678)	(0.944)
FinancialWealth (thousands)	0.036	0.082	0.001	0.075	0.016
	(0.934)	(0.026)	(0.004)	(0.013)	(0.020)
Gender	−2703.232	−16.998	−3.631	−1.039	2.042
	(1579.544)	(12.381)	(2.458)	(4.194)	(8.600)
DCValue (thousands)	−0.225	0.004	0.001	−0.003	−0.003
	(0.315)	(0.007)	(0.001)	(0.002)	(0.004)
YearsSinceRetirement	−249.416	−0.629	−0.233	−0.036	9.026
	(1553.812)	(7.934)	(1.521)	(2.847)	(6.418)
OwnsHouse	−10 411.204	113.855	19.952	27.670	41.480
	(5926.638)	(15.256)	(3.138)	(5.087)	(8.864)
StatePension	224.157	−2.088	−0.419	−0.290	0.652
	(405.619)	(2.071)	(0.413)	(0.634)	(1.429)
PostReform:DCPension	2967.665	−11.682	−1.088	−5.426	36.704
	(1798.151)	(29.911)	(5.955)	(10.089)	(30.007)
PostReform:DBPension	3430.376	−38.793	−5.364	−15.671	−14.186
	(2132.747)	(24.244)	(4.753)	(8.451)	(19.921)
Num.Obs.	933	1380	1381	1391	1007
R2	0.030	0.053	0.031	0.103	0.033
R2 Adj.	0.018	0.045	0.022	0.095	0.021
AIC	21 514.1	18 883.7	14 428.0	16 023.3	12 719.0

Table 4 shows these results. The post reform variable now tells us that total consumption decreased but food consumption increased a little and clothing consumption decreased. The interactions at the bottom of the table show us what happened to individuals with a given pension type relative to the reference cohort which has no pension. Those with only a DC pension had an increase in total consumption which was lower than that for those with a DB pension but higher than those with no pension. Only for consumption on clothes did DC consumption increase more than the other groups. As above, the only variables that are significant at the 5% level are financial wealth and whether the individual owns their house.

We can also test whether treatment intensity is correlated with larger increases in spending. Those who have more money in a DC pension, and those with more financial wealth overall, would be impacted by the policy to a greater extent than those with smaller pensions. So, I interact the policy with the treatment variable. As in Table 3, this regression only uses those individuals who have a DC pension.

To be precise I run:

$$Cons_{it} = \gamma X_{it} + \beta PostReform_{it} * DCValue_{it} + \epsilon$$

Table 5: DC Pension Size interaction

	TotalConsump	FoodConsump	FoodConsumpIn	FoodConsumpOut	ClothingConsump
(Intercept)	1347.198	571.090	77.009	220.315	40.944
	(745.238)	(346.747)	(68.914)	(122.712)	(217.875)
PostReform	74.604	9.797	0.123	11.064	27.427
	(69.978)	(27.205)	(5.366)	(9.226)	(24.871)
RetiredAge	−4.652	−3.172	−0.073	−2.585	−0.295
	(10.447)	(5.435)	(1.089)	(1.893)	(3.609)
FinancialWealth (thousands)	0.229	0.172	0.013	0.111	−0.012
	(0.114)	(0.050)	(0.010)	(0.025)	(0.053)
Gender	−19.457	−35.355	−6.937	−6.007	13.359
	(63.228)	(28.103)	(5.502)	(10.149)	(24.880)
DCValue (thousands)	−0.009	0.022	0.006	−0.004	−0.002
	(0.027)	(0.035)	(0.008)	(0.004)	(0.009)
YearsSinceRetirement	−1.902	−7.906	−0.268	−7.741	6.092
	(44.666)	(16.767)	(3.225)	(6.186)	(14.714)
OwnsHouse	−261.541	101.085	20.990	10.656	73.604
	(196.144)	(37.911)	(7.293)	(14.787)	(16.328)
StatePension	−14.040	−4.125	−1.256	1.258	−3.040
	(9.566)	(4.105)	(0.841)	(1.265)	(4.052)
PostReform:DCValue (thousands)	−0.003	−0.022	−0.005	0.000	−0.002
	(0.045)	(0.035)	(0.008)	(0.004)	(0.017)
Num.Obs.	209	326	326	330	221
R2	0.068	0.066	0.051	0.102	0.035
R2 Adj.	0.026	0.039	0.024	0.076	−0.006
AIC	3156.1	4500.7	3452.4	3836.7	2897.0
BIC	3192.9	4542.4	3494.1	3878.5	2934.4
Log.Lik.	−1567.065	−2239.361	−1715.225	−1907.357	−1437.504
RMSE	436.58	232.82	46.64	78.33	161.68
Std.Errors	HC3	HC3	HC3	HC3	HC3

Table 5 shows the results. Surprisingly, a larger DC pension pot is not associated with a greater increase in consumption. And although the reform is again associated with an increase in consumption, especially for food out of the house and clothing, this affect is decreasing with the size of the pension pot.

The defined contribution pension pot size variable comes from work done by the IFS. This was discontinued after wave 5 so it is no longer possible to identify pension wealth in this way. For the above table pension wealth from the last available year for an individual was given a real return of 3% and compounded until year of interview. Given that this is an imperfect measure, I also run the regression with financial wealth interacted with the treatment variable.

Table 6: DC Financial Wealth interaction

	TotalConsump	FoodConsump	FoodConsumpIn	FoodConsumpOut	ClothingConsump
(Intercept)	1214.548	360.272	66.936	58.795	94.460
	(808.872)	(305.425)	(56.441)	(152.440)	(201.251)
PostReform	138.658	10.862	−2.901	24.129	28.874
	(96.625)	(29.947)	(5.497)	(13.280)	(37.594)
RetiredAge	−2.021	0.625	0.109	0.331	−1.204
	(11.916)	(4.937)	(0.898)	(2.568)	(3.294)
FinancialWealth (thousands)	0.386	0.161	0.011	0.106	0.053
	(0.173)	(0.092)	(0.013)	(0.048)	(0.095)
Gender	0.534	−48.776	−7.307	−17.512	13.277
	(67.319)	(26.842)	(4.917)	(12.771)	(25.149)
YearsSinceRetirement	−20.638	−10.659	−1.027	−6.952	−7.062
	(49.857)	(18.146)	(3.092)	(10.158)	(18.771)
OwnsHouse	−292.319	91.610	20.945	0.946	71.709
	(187.668)	(41.548)	(6.964)	(22.074)	(15.806)
StatePension	−18.997	−5.717	−1.180	−0.612	−0.385
	(9.802)	(4.168)	(0.761)	(2.177)	(4.426)
PostReform:FinancialWealth (thousands)	−0.094	0.047	0.014	−0.011	−0.102
	(0.423)	(0.105)	(0.017)	(0.061)	(0.160)
Num.Obs.	223	361	361	365	235
R2	0.096	0.075	0.054	0.058	0.027
R2 Adj.	0.062	0.053	0.032	0.037	−0.007
AIC	3404.4	5037.4	3806.0	4595.1	3097.3
BIC	3438.5	5076.3	3844.9	4634.1	3131.9
Log.Lik.	−1692.215	−2508.723	−1892.982	−2287.542	−1538.668
RMSE	477.93	252.25	45.82	127.52	168.78
Std.Errors	HC3	HC3	HC3	HC3	HC3

Table 6 contains these results and shows a similar pattern to Table 5. The reform is associated with an increase in consumption, but more financial wealth decreases the effect rather than making it stronger. This could be because those with higher levels of financial wealth have more assets in other savings apart from retirement savings Cribb and Karjalainen (2023) and therefore the DC pot is a smaller proportion of overall assets, and thus the policy change did not affect them as much.

In conclusion, the results in the tables above show that in the basic regression discontinuity setup there is an impact of the policy reform on consumption, and this effect is stronger for consumption goods we would associate with a large increase in income. However, this is imprecisely estimated, and when we use a difference in difference identification method this effect disappears. Moreover, when we interact with a proxy for treatment strength (financial wealth or pension size) the effect is smaller the stronger the treatment.

Theoretically, a null change in consumption is evidence for a bequest motive explaining a lack of annuitisation rather than pessimistic life expectancies being the cause. In the next section I simulate a lifecycle model for individuals in the ELSA dataset and **some thing that gives a taster of the results to come in the next section**

3 Life cycle theory

In the second part of the paper I first solve a modified retirement lifecycle model and then use data from the solved lifecycle model in similar regressions to the ones above.

The problem that retirees face is as follows. Every period retirees solve:

$$V_t(a_t, y) = \max_{a_{t+1}, c_t} \{u(c_t) + p_t B(a_{t+1}) + \beta(1 - p_t)V_{t+1}(a_{t+1}, y)\}$$

subject to their budget constraint

$$c_t = a_t(1 + r) - a_{t+1} + y$$

where a_t are asset holdings in time t, y is constant income for all periods, V_t is value in period t, p_t is probability of death in period t and $B()$ is a bequest function. Income can come either from state pensions, defined benefit pension plans or purchased annuities.

$$u(c_t) = \frac{c_t^{1-\sigma}}{1 - \sigma}$$

In some specifications retirees can leave bequests, I use the bequest function from Lockwood (2012).

$$B(a_{t+1}) = \big(\frac{m}{1-m}\big)^{\sigma} \frac{\big(\frac{m}{1-m}c_0 + a_{t+1}\big)^{(1-\sigma)}}{1-\sigma}$$

Where a_{t+1} is the amount left at death, m is a measure of bequest motive strength and c_0 is a minimum amount of consumption that individuals want. I pick values of $m = 0.95$ and $c_0 = 20,000$ since these generate low rates of annuitisation, for comparison, Lockwood picks $m = 0.96$ and $c_0 = 18,000$ **Check all of this**

First, I discretise the state space. I create a grid from 500 to 50,000 incrementing by 500 for income and 1000 to 500,000 incrementing by 1000 for financial assets. I solve the retirees problem using backward induction. At age 110 there is certainty of death so any leftover assets are carried over into the next period and bequested. This means that the value at the end of the final period is either 0 (if we do not allow a bequest motive) or the value of bequests. I then take this value function and solve an individual's final period problem, choosing assets next period (i.e. those to bequest) and how much to consume.

Using the optimal policy function in the last period, which is assets next period that maximise the utility function and the value function this period given all the potential income and asset states, I calculate the value of the last period. This is then used in the problem the year before that. I repeat this process back to the age of retirement to obtain optimal consumption amounts for each year of retirement and associated value functions.

To simulate the ELSA data I solve this retirement problem for each new retiree in the data set dependent on their objective probability of death each period. I estimate with subjective life expectancies and objective life expectancies. I also estimate the model both with and without a bequest motive which was picked to roughly fit the real annuity rates seen in the data.

In retiree's first year of retirement I allow them to choose to annuitise some of their wealth. In practical terms this is moving down the asset grid but up the income grid and seeing if the value of being in that position is better than where the individual is currently. To assess this trade-off I calculate the annual annuity payment that follows from a given annuity cost. I calculate this using objective life tables from the ONS using the following equation:

$$Ann = \delta * C * \left[\sum_{t=Retage}^{110} \frac{1 - p_{t|Retage}}{(1+r)^{t-Retage}}\right]^{-1}$$

Where C is the one-off payment, δ is a factor that controls the 'money's worth' of annuity and $p_{t|Retage}$ is the probability of death at age t conditional on being age $Retage$. So individuals can move C on the asset grid for gaining Ann on the income grid for the rest of their lives.

I also simulate the expected change in consumption given different rates of annuitisation versus no annuitisation. The benefit of simulating an individual's decision is that we can directly compare what they would have consumed with what they actually consumed, and we can replicate the empirical analysis using the solution to the lifecycle model.

I first round an individuals financial wealth to the nearest point on the discrete asset grid, and do likewise for an individuals state pension income. I then take the treatment group and evaluate their consumption in the year of interview with an annuity given that they annuitised some portion of their wealth in their retirement year. I also evaluate consumption without annuitisation. I then use the same specification as above, but now the treatment group is the values of consumption without annuitisation.

Because I discretised the state space, annuity prices are rounded down to the nearest income grid point. This means that for some individuals with low assets half of their financial wealth does not buy them at least one grid point of annuity income. I do not let these individuals annuitise, setting consumption with and without an annuity to the same amount. I also present the average implied loading factor δ, although I set this to 0.9 when calculating annuity prices, because of rounding down this is lower.

Table 7: Simulated standard lifecycle models

	DCOnly	AllDataDCInteraction	DCOnlyPensionInt	DCOnyFinancialInt
(Intercept)	−9176.027	−8631.599	−9158.766	−8519.286
	(1537.858)	(892.527)	(1531.497)	(1337.257)
PostReform	−58.408	103.722	−73.675	212.066
	(76.827)	(74.159)	(78.557)	(98.094)
RetiredAge	144.920	131.537	144.701	132.408
	(24.546)	(13.938)	(24.444)	(21.379)
FinancialWealth (thousands)	54.048	53.925	54.073	55.187
	(0.577)	(0.401)	(0.581)	(0.794)
Gender	186.306	248.179	183.248	192.530
	(68.859)	(53.298)	(69.090)	(63.330)
DCValue (thousands)	0.006	0.004	−0.036	
	(0.014)	(0.013)	(0.064)	
YearsSinceRetirement	−13.571	−45.360	−12.067	−3.755
	(54.511)	(30.580)	(54.795)	(50.185)
OwnsHouse	44.975	386.812	45.963	73.291
	(139.122)	(69.281)	(140.011)	(121.295)
StatePension	1060.302	1071.860	1061.238	1056.810
	(11.484)	(7.454)	(11.493)	(11.095)
DCPension		−56.617		
		(57.249)		
DBPension		1.094		
		(52.166)		
PostReform:DCPension		−63.938		
		(89.166)		
PostReform:DBPension		−189.631		
		(91.028)		
PostReform:DCValue (thousands)			0.052	
			(0.065)	
PostReform:FinancialWealth (thousands)				−2.497
				(1.026)

Table 7 shows the results from the bequest models.

Table 8: Simulated bequest lifecycle models

	DCOnly	AllDataDCInteraction	DCOnlyPensionInt	DCOnyFinancialInt
(Intercept)	−6262.097	−6051.382	−6237.363	−6979.445
	(1395.256)	(554.952)	(1387.059)	(1432.846)
PostReform	54.573	8.347	32.696	118.005
	(60.574)	(50.505)	(61.826)	(87.493)
RetiredAge	104.248	97.466	103.934	116.919
	(22.583)	(8.883)	(22.451)	(24.166)
FinancialWealth (thousands)	49.165	49.778	49.201	49.625
	(0.367)	(0.223)	(0.372)	(0.604)
Gender	197.469	212.099	193.086	212.948
	(55.239)	(34.701)	(55.490)	(58.664)
DCValue (thousands)	0.023	0.016	−0.038	
	(0.011)	(0.012)	(0.023)	
YearsSinceRetirement	−0.348	−25.177	1.806	−1.253
	(37.150)	(20.957)	(37.050)	(35.945)
OwnsHouse	119.545	345.888	120.960	85.961
	(102.307)	(54.727)	(102.478)	(104.125)
StatePension	1003.958	1023.360	1005.300	984.787
	(10.205)	(5.555)	(10.226)	(21.066)
DCPension		−146.769		
		(45.300)		
DBPension		34.795		
		(39.084)		
PostReform:DCPension		102.691		
		(65.467)		
PostReform:DBPension		−116.878		
		(61.954)		
PostReform:DCValue (thousands)			0.074	
			(0.028)	
PostReform:FinancialWealth (thousands)				−0.903
				(0.709)

Table 8 shows the results from the bequest models.

Each column in the table shows a different model. Column 1 shows the model with no bequest motive where individuals use objective life probabilities from ONS, column 2 uses

Also get some plots of consumption in early retirement with and without annuities for the different model types

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