ESRI

Working Paper No. 572

September 2017

Do youth access control policies stop young people smoking? Evidence from Ireland

Michael Savage*

Abstract: Increasing the legal age at which individuals can buy tobacco has become an increasingly common policy tool aimed at reducing youth smoking. There remains, however, some debate on whether such policies are an efficient use of resources. Evidence thus far has either (i) relied on local or regional Minimum Legal Age (MLA) reforms which suffer from a range of potential endogeneity and spillover biases, or (ii) rely on the use of adult population control groups that are, in many cases, unsuitable. Missing from the debate on the effectiveness of MLA policy is an analysis of a national increase in an MLA, where a suitable control group of identically aged adolescents exists. The 2001 MLA reform in the Republic of Ireland, which increased the MLA from 16 to 18, offers natural experiment conditions whereby issues relating to endogeneity, spillover effects and unreliable control groups are made redundant. The outcomes examined in the analysis are also novel compared to previous research, as both intensity of current smoking behaviour and previous smoking experience are examined. The evidence found here strongly supports increases in MLAs as an effective policy tool to reduce youth smoking rates.

*Corresponding Author: michael.savage@esri.ie

Keywords: Tobacco Control, Legal Smoking Age, Youth Smoking, Ireland, Difference-in-Difference, HBSC

Acknowledgements: The author thanks ISSDA for providing access to the SLÁN data [accessed via the Irish Social Science Data Archive website, www.ucd.ie/issda], the Northern Ireland Statistics and Research Agency Central Survey Unit for providing access to YPBAS [accessed via the UK Data Archive], Prof. Saoirse Nic Gabhainn for facilitating access to the HBSC data through the HBSC Data Management Center at the University of Bergen, the CSO for providing access to the SILC data, and the ESRI for providing access to LII. The author thanks Brendan Walsh, Conor Keegan, Karina Doorley and Claire Keane for comments.

1. Introduction

Minimum legal age (MLA) legislation for purchasing tobacco has become a common policy measure to combat underage smoking worldwide. In the US, the 2009 Family Smoking Prevention and Tobacco Control Act set a national MLA of 18. A growing number of states or regional authorities in the US have increased the MLA to as high as 21, including New York City, California and Hawaii in 2016, and Oregon in 2017.[1] In Canada, where the MLA for purchasing tobacco is also 18, there is growing debate about the merits of increasing the MLA to 21 or higher.[2] In Europe, only Austria remains of the EU countries to have an MLA below 18, though none have yet increased this beyond 18.

Despite this ongoing policy movement, there is some debate on whether such policies are an efficient use of resources. Fichtenberg and Glantz (2002) strongly argued against the use of youth access interventions. Based on a meta-analysis of nine studies examining local or regional youth access interventions on youth smoking prevalence, they found no evidence of differences in youth smoking rates in communities with youth access interventions compared to those without. On this basis, they argued that "tobacco control advocates should abandon this strategy and devote the limited resources that are available for tobacco control toward other interventions with proven effectiveness". DiFranza (2012) criticised the Fichtenberg and Glantz meta-analysis, arguing that it systematically excluded up to 90 per cent of the literature from consideration. In a meta-analysis of more than 400 published articles and 400 government reports on a range of topics including youth smoking behaviour, retailer responses to MLAs, and changes in the sources of tobacco for youth as a result of MLAs, DiFranza found many examples of interventions in which the disruption of the sale of tobacco to minors was followed by substantial declines in youth smoking. He therefore concluded that "all available evidence indicates that interventions that successfully disrupt the sale of tobacco to minors can be expected to reduce the rate of tobacco use among adolescents".

Assessments of MLAs are often based on local or regional MLAs on youth smoking, particularly in the US. Schneider et al. (2016) compared youth smoking trends in Needham, Massachusetts, a region that raised the MLA from 18 to 21 in 2005, with those of 16 surrounding communities. They found a significantly larger decrease in 30-day smoking among youths in Needham than the surrounding regions. Forster et al. (1998) conducted a randomised trial involving 14 Minnesota communities, imposing youth access controls in seven of these communities. They again found a significant effect of these policies on adolescent smoking rates in the treatment communities compared to the control communities. Conversely, in a two-year controlled study, Rigotti et al. (1997) assessed sales of tobacco to minors and young people's access to and use of tobacco in six Massachusetts communities and found that enforcing tobacco-sales laws improved merchants' compliance and reduced illegal sales to minors but did not alter adolescents' smoking.

[1] See Apollonio and Glantz (2002) for a detailed review of minimum age of legal access to tobacco legislation in the US.

[2] See, for example, the Ontario Tobacco Research Unit (2015).

Evidence on the impact of MLAs outside of the US is relatively sparse, though some analyses exist. Millet et al. (2011) and Fidler et al. (2010) separately examined the impact of a 2007 increase in the MLA from 16 to 18 in the UK. Millet et al. relied on repeated cross-sections of 11-15 year olds and found a significant decrease in the probability of smoking after the increase in the MLA, though no control group was used. Fidler et al. used young adults in the UK as a control group, and found a greater fall in smoking prevalence in 16–17-year-olds following an increase in the MLA than in older age groups. Tutt et al. (2009) compared outcomes following an intervention in the Central Coast area that increased the MLA from 16 to 18 to the rest of New South Wales (NSW) and Australia, and found that current smoking rates among adolescents in NSW declined by significantly more than any of their control groups. In a country level study involving 27 European countries, Schroner et al. (2008) found that MLAs were associated with a higher prevalence of daily smoking, though suggested that this finding was a result of endogeneity biasing their results.

Missing from the debate on the effectiveness of increasing MLAs in reducing youth smoking is an analysis of a national increase in an MLA, where a suitable control group consisting of identically aged teenagers unaffected by the increased MLA exists. The use of community or regional MLA increases as natural experiments leaves analyses open to a range of issues, including endogeneity of implementation of policy, and spill-over effects between treatment and control regions. Alternatively, analysing national MLA policy using young adults as the control group has been criticised on the basis that smoking among young adults can be driven by entirely different processes compared to underage smoking; examples here include the presence of workplace smoking policies that affect young adults but do not affect adolescents. Fidler et al., for example, do not account for the 2007 introduction of a workplace smoking ban in the UK that may bias their results when using young adults as a control group for smoking rates among adolescents.

The 2001 increase in the MLA from 16 to 18 in the Republic of Ireland (hereafter referred to as Ireland) offers natural experiment conditions whereby these issues are made redundant. The compulsory and nationwide nature of the increase in the MLA ensures that endogeneity issues with the communities or regions that choose to implement voluntary smoking bans are negated. A natural control group exists among identically aged youth from Northern Ireland, where no such increase in the MLA took place over the same time period. The availability of identical information on smoking rates among the treated (adolescents in Ireland) and non-treated (adolescents in Northern Ireland) both before and after the MLA increase in Ireland enables accurate measurement of the impact of the increase in the MLA on youth smoking rates through a difference-in-differences (DiD) identification strategy.

The analysis in this paper provides new evidence in the debate over the growing use of MLAs to reduce youth exposure to tobacco. This is the first study I am aware of that examines the impact of an increase of MLAs on smoking behaviour among adolescents, using a national increase in the MLA

with an identically aged control group as the case study. The outcomes used in the analysis are also novel compared to previous research, in that both intensity of current smoking behaviour and previous smoking experience are examined. The impact of the MLA increase in Ireland is analysed with respect to three related outcomes: (i) smoking prevalence defined by currently smoking at least once a week, (ii) smoking prevalence defined by currently smoking at all, and (iii) smoking history defined by having ever smoked at least one cigarette. To ensure comparability with previous research, the DiD estimates are replicated using additional control groups consisting of young adults from Ireland.

The findings provide strong evidence in support of MLAs in reducing smoking among adolescents. Current smoking prevalence and previous smoking experience significantly decreased among adolescents in Ireland following the increase in the MLA compared to adolescents in Northern Ireland. Results were mirrored when young adults from Ireland were used as alternative control groups. The evidence found here therefore strongly supports increases in MLAs as an effective policy tool to reduce youth smoking rates.

2. Context

The majority of current smokers first smoked before adulthood. In the US, for example, 88 per cent of current smokers had their first cigarette before they were 18, while 37 per cent of adults who had ever smoked cigarettes reported trying their first cigarette by 14 years of age (U.S. Department of Health and Human Services, 2012). As shown in Section 4, a similar pattern of youth exposure to tobacco exists in Ireland, where, prior to the increase in the MLA in 2001, 60 per cent of 14 and 15 year olds had smoked at least one full cigarette. In Northern Ireland, almost half of the same age group had smoked at least one full cigarette.

Preventing youth uptake of smoking was a key pillar of the national action plan outlined in *Towards a Tobacco Free Society (2000)*, a report by the Tobacco-Free Policy Review Group in Ireland. One of the key policy recommendations emanating from the report was to increase the MLA for purchasing tobacco in Ireland. In 2001, Section 45 of the Public Health (Tobacco) Act, 2002 was enacted, legally increasing the MLA from 16 to 18. From an evaluation viewpoint, one of the key parameters in determining the success of the policy is whether or not the policy was enforced in practice. In 2007, the Office of Tobacco Control[3] undertook a national retail audit, part of which was to evaluate enforcement of the MLA throughout Ireland. Part of their approach was to collect information from specifically recruited minors aged 14 to 17 who attempted to purchase tobacco in over 1,300 retail establishments across Ireland. Results were mixed. Nationally, the percentage of retailers who refused to sell cigarettes to underage youth was 52 per cent. There was a clear pattern of enforcement across age groups however: 88 per cent of 14 year olds, 68 per cent of 15 year olds, 37 per cent of 16 year olds and 48 per cent of 17 year olds were refused tobacco. No comparable audit took place before 2001, so it is unclear whether the relatively high rate of refusal, or policy compliance, to 14 and 15 year olds was due to the policy change.

[3] Now called the National Tobacco Control Office.

Due to the young age of first experimentation with tobacco both in Ireland and elsewhere, and the relatively low level of enforcement of the MLA in Ireland among 16 and 17 year olds, the focus in this paper is on the effect of the MLA increase on smoking among 14 and 15 year olds in Ireland. While it was illegal for this age cohort to be sold tobacco before 2001, the increase in the MLA in 2001 raises the threshold for purchasing tobacco for all youths. Strictly, the analysis is therefore an examination of whether the increased MLA from 16 to 18 affects smoking among 14 and 15 year olds.

3. Methodology

In this section, the design of the DiD estimator is discussed. Two groups are identified: a group of 14 and 15 year olds attending school in Ireland (treatment group), and 14 and 15 year olds attending school in Northern Ireland (control group)[4]. Two time periods are then identified: before and after the increase in the MLA from 16 to 18 in 2001. Let;

- $q^{o,t}$= outcome of treated before MLA increase
- $q^{1,t}$= outcome of treated after MLA increase
- $q^{o,c}$= outcome of control group before MLA increase
- $q^{1,c}$ = outcome of control group after MLA increase

Using the DiD methodology, the difference between the change in rates of smoking in each group before and after the smoking ban is identified as the impact of the policy change. For the treatment group the total difference in smoking rates before and after the ban is $q^{1,t} - q^{o,t}$. For the control group, the total difference in smoking rates before and after the ban is $q^{1,c} - q^{0,c}$. The DiD equation is therefore expressed as;

$$DiD = (q^{1,t} - q^{o,t}) - (q^{1,c} - q^{0,c}) \qquad (1)$$

If the increase in the MLA reduced smoking among 14 and 15 year olds in Ireland, the DiD coefficient will be negative. This is shown by the following reasoning. The expected sign of the $(q^{1,t} - q^{o,t})$ term is negative. We assume that the cost (broadly defined) of obtaining cigarettes for the treatment group increases after the increase of the MLA. Therefore, we would expect the rates of smoking among the treatment group to fall due to the MLA policy. This implies that the first term in the equation should be negative, as we expect $q^{o,t} > q^{1,t}$.

Given general downward trends in smoking rates over time, we would expect the $q^{1,c} - q^{0,c}$ term to be at least non-positive. However, based on the common trend assumption upon which the DiD technique relies, there is no factor that changes smoking rates in the control group more than it does for the treatment group. As such the model predicts that the DiD should be negative. A DiD

[4] Given that Ireland and Northern Ireland share an open land border, it is quite possible that some children live in one country and go to school in the other. It is not possible to identify these children, so this should be borne in mind when interpreting results. However, the frequency at which this occurs is not likely to be high enough to significantly affect results.

equal to zero implies that the MLA increase had no effect on smoking rates among 14 and 15 year olds in Ireland. A positive DiD implies that youth smoking rates in Ireland *increased* relative to Northern Ireland. This scenario has been discussed previously in the literature, whereby banning tobacco consumption among adolescents increases the perception that "smoking is for adults", which arguably makes smoking even more attractive to teens (Ling et al., 2002). Indeed, Katzman et al. (2008) found evidence that the presence of laws related to youth purchase, use and possession in the US were positively related to days smoked among individuals that borrowed (rather than bought) cigarettes. They highlighted the importance of the borrowing market as a source for cigarettes when teenagers find it more difficult to obtain cigarettes through retail outlets.

3.1 Empirical Estimation

We use regression analysis to estimate the DiD term. The estimator of the DiD coefficient, δ_1, can be estimated in the equation:

$$y = \beta_0 + \delta_0 dT + \beta_1 dG + \delta_1 (dT * dG) + \varepsilon \qquad (2)$$

where, y is the outcome of interest, dT is a dummy variable for the time periods and dG is a dummy variable for the groups. The dummy dG equals one for the treatment group and zero otherwise, and captures the difference between the control and treatment groups before the policy change. The dummy dT equals one for the treatment period and zero for the control period, and captures the aggregate factors that affect the two groups over time. The use of δ_1 means that both group-specific and time-specific factors are controlled for.

The coefficient δ_1 captures the effect of the interaction between the policy change and the treatment group as the term dT * dG only takes a value of unity for those observations in the treatment group in the treatment period. We can also estimate the above equation including several independent variables to control for other factors that may affect the relationship. In light of the debate on the appropriation estimation method for this regression (see Ai and Norton (2003) and Puhani (2012) for details), the results in this paper are estimated using a linear probability model. As a robustness check of our results, we also used a probit model; results remain robust.

4. Data

The primary source of data used this analysis comes from the Health Behaviour in School-Aged Children (HBSC) study[5]. As the increase in the MLA in Ireland was introduced in September 2001, the control period data comes from the 1998 wave of the HBSC and the treatment period data comes

[5] The full title of the survey is the "Health Behaviour in School-aged Children: WHO Collaborative Cross-National study". HBSC Ireland is part of an international study carried out in collaboration with WHO/EURO. The 1998 Irish survey was conducted by Dr. Saoirse Nic Gabhainn and Professor Cecily Kelleher at NUI Galway. For details, see http://www.nuigalway.ie/hbsc. The 2002 and 2006 waves are available at http://www.hbsc.org/

from the 2002 wave of the survey. The 2006 wave is also used to conduct a placebo time period sensitivity test on results. The HBSC is a school-based survey of 11 to 15 year olds on a number of health related topics. In each case, data was collected between March and June of the year. The results presented in the paper are based on 14 and 15 year olds only, though sensitivity checks of all results were carried out using the full sample, and results remain robust.

We construct a number of control groups for the difference in difference estimation. The primary control group is a group composed of a similar cohort of adolescents from Northern Ireland.[6] The Young Persons' Behaviour & Attitudes Survey (YPBAS) data contains very similar information as the HBSC, but contains a sample of Northern Irish schoolchildren. As shown in Table I, the waves of the YPBAS survey do not fully coincide with the HBSC data. The control period data comes from the 2000 wave of YPBAS, while the treatment period data comes from the 2003 wave. The potential impact of using different years for the two surveys is discussed when interpreting the results.

Further control groups are constructed from three surveys that include smoking behaviour information on young adults in Ireland. The Survey of Lifestyle and Nutrition (SLÁN) was conducted in 1998 and 2002, perfectly coinciding with the waves of the HBSC data. SLÁN is a survey of the population of individuals aged 18 and over in Ireland, and contains information on current and historical smoking behaviour. From this survey we construct control groups of young adults in Ireland, estimating multiple DiD regressions by ranging the maximum age in the control group in yearly steps from 20 to 30. This approach produces 11 different estimates of δ_1 based on the SLÁN control group.

A similar approach is adopted using the Living in Ireland Survey (LIS) and the Survey of Income and Living Conditions (SILC). LIS formed the Irish component of the European Community Household Panel: an EU-wide project, co-ordinated by Eurostat, to conduct harmonised longitudinal surveys dealing the social situation, financial circumstances and living standards of European individuals and households. It was conducted annually from 1994 to 2001 inclusive. Using LIS respondents, the control period data therefore comes from the 1998 wave of LIS while the treatment period information comes from the 2001 wave of the survey, both based on young adults aged at least 18. Although 2001 was the year that the increase in the MLA took place in Ireland, individuals aged 18 or more should remain unaffected by the policy reform and so remain a valid control group. Nevertheless, to guard against potential bias introduced by having the "after policy change" information for the control group coming from the same year as the policy change itself, a final control group is constructed using young adults from the 2003 wave of SILC.[7]

[6] See Appendix for map of the island of Ireland, which is divided into two countries: The Republic of Ireland, and Northern Ireland.

[7] Neither LIS nor SILC was conducted in 2002, so we do not have the option of using either survey in the same year as the treatment period information from the HBSC.

Table I summarises the identification strategy and the relevant data sources. The primary model compares the change in outcomes among 14 and 15 year olds in Ireland using the HBSC data with the change in outcomes among 14 and 15 year olds in Northern Ireland using the YPBAS data. Further models compare the change in outcomes among the same group of adolescents in Ireland, with young adults in Ireland from the SLÁN, LIS and SILC surveys.

*****TABLE I ABOUT HERE**

4.1 The Outcome Variables

Three smoking related outcomes are examined using the data described above. The HBSC and YPBAS data both contain information on whether each respondent currently smokes, and how often they smoke. Though categories of intensity vary slightly between surveys, it is possible to identify in each wave of each survey whether a respondent smokes at least once a week, less than once a week, or doesn't smoke at all. The first two outcomes of interest are therefore "Regular Smoker", defined as smoking at least once a week, and "Regular or Occasional Smoker", defined as smoking at all.

In each wave of the HBSC and YPBAS data it is also possible to identify whether a respondent has ever smoked at least one full cigarette. This outcome therefore relates to previous smoking experience rather than current smoking behaviour.

SLÁN and LIS contain similar information on both current smoking behaviour and previous smoking experience, though slight differences in question wording and outcome categories should be flagged here. In each case, current smokers are categorised as either "regular" or "occasional" smokers. We equate regular smokers in the adult surveys with adolescents who smoke "at least once per week". This is the first outcome of interest: the probability of being a regular smoker. All smokers, regular or occasional, are equated with all smokers in the youth surveys, and the outcome is defined as "Regular or Occasional Smoker". This is the second outcome of interest: the probability of smoking at all. SILC contains only binary information on whether a person smokes: yes or no. All individuals in SILC who respond that they do smoke are equated to the "regular or occasional" smokers in the HBSC.

The final outcome of interest, previous experience with smoking, should be interpreted with some degree of caution when using the young adult control groups. In SLÁN and LIS, each respondent is asked if they have ever smoked, with possible answers of "yes" or "no". This is somewhat different to the question asked to the adolescents in HBSC: "Have you ever smoked tobacco? (At least one cigarette, cigar or pipe)". Using this outcome in the DiD framework with young adults as the control group should therefore be interpreted simply as a robustness check on the main model, which uses the adolescents from Northern Ireland as the control group.

4.2 What can we control for?

It is straightforward to add covariates to the DiD regression framework to control for group specific trends. A constraint of using separate datasets for treatment and control groups is that each outcome and covariate should be identically measured in each survey. Table A in the appendix shows the full list of variables that are measured in each wave of both surveys, and are suitable to be used as covariates in the analysis. The covariates include family status and relationship to other family members, the presence of close friends, feelings about school and schoolwork, frequency of consumption of alcohol, fruit and vegetables, and frequency of physical activity. When using young adults as the control group, the covariates available and suitable to use are more restricted: age and gender are included in all models, with an indicator of stress and alcohol consumption also included when using the SLAN control groups. [8] All econometric results shown in the following section are based on regression models with these covariates included; results are robust to excluding all or any of the covariates.

5. Results

5.1 Summary Statistics

Figure 1 compares the prevalence of smoking among 14 and 15 year olds in Ireland (HBSC data) before and after the increase in the MLA with the prevalence of smoking among each of the control groups (YPBAS, SLÁN and LIS data)[9]. Only among the treatment group is there a statistically significant fall in the proportion of smokers, defined either by regular smoking (Figure 1a) or smoking at all (Figure 1b). As expected, the prevalence of smoking among adolescents is significantly lower than among the older age control groups. Smoking prevalence is somewhat higher in SLÁN compared to LIS or the LIS/SILC combination, though patterns over time are similar. Without yet accounting for any covariates that may affect smoking patterns, Figure 1 provides suggestive evidence that the increase in the MLA resulted in a decrease in smoking prevalence among 14 and 15 year olds in Ireland, when compared against either 14 and 15 year olds in Northern Ireland, or young adults in Ireland.

*****FIGURE 1 ABOUT HERE**

Figure 2 examines how the proportion of respondents in each of the surveys that have ever smoked changed before and after the increase in the MLA. As before, only among the treatment group do we observe a statistically significant decrease, again providing suggestive evidence of a potentially causal relationship. When comparing the younger cohorts to the older cohorts here, it is important to recall that younger cohorts are asked have they ever smoked at least one full cigarette, while older cohorts (in different surveys) are asked have they ever smoked. Difference in interpretation of

[8] See Appendix for description of how these variables was constructed.

[9] For clarity, the smoking rates presented in Figures 1- 3 for young adults in Ireland (LIS, LIS/SILC, SLÁN) are means for young adults aged 18-25. When estimating the DiD coefficient econometrically, 11 different control groups from each survey are constructed, ranging from young adults aged 18 to 20, to young adults aged 18 to 30. This is described in more detail in Section 3.

these questions are likely to explain why the frequency at which younger cohorts respond that they have ever smoked are at least as high as among older cohorts. The HBSC – YPBAS comparison is therefore most reliable in this setting, though the consistency of results across the additional control group suggests these comparisons may also be valid.

*****FIGURE 2 ABOUT HERE**

Econometric Results

Econometric estimation of the DiD coefficient, controlling for the range of covariates discussed in Section 4, confirms the results suggested in Figures 1 and 2. As shown in Table II, compared to 14 and 15 year olds in Northern Ireland, 14 and 15 year olds in Ireland were 5 percentage points less likely to smoke at least once a week following the increase in the MLA from 16 to 18 in Ireland. The results are stronger when examining the probability of smoking at all; the DiD coefficient in this case is 8 percentage points. Finally, the probability of having ever tried at least one full cigarette fell by 10 percentage points among adolescents in Ireland compared to their counterparts in Northern Ireland.

These results are robust to including 11-13 year olds in both the treatment and control groups, and are slightly stronger for 14 year olds than for 15 year olds, though differences to those presented in Table II are small.

*****TABLE II ABOUT HERE**

Figure 3 presents the DiD coefficients from a series of regressions using the control groups from the surveys of young adults in Ireland. In each case, each point along the curve is an estimate of the DiD coefficient using a control group with a maximum age displayed along the x-axis. The results mirror those presented in Table II. With the exception of the control groups with the lowest maximum age due to low sample sizes, the DiD coefficients for each of the outcomes of interest are highly comparable to those with the YPBAS control group. Increasing the MLA from 16 to 18 in Ireland produced a 10 percentage point reduction in the likelihood of 14 and 15 year olds having ever tried smoking, and a five percentage point reduction in the probability of being a current smoker. Only when estimating the probability of being a current smoker with the SLÁN control group is the estimate of the DiD coefficient insignificantly different from zero.

*****FIGURE 3 ABOUT HERE**

Table III presents results from a number of sensitivity checks on the results. One alternative explanation for the results is that risky behaviours changed among the Irish sample of 14 and 15 year olds relative to all others during this time period. To examine this hypothesis, the same DiD regression is estimated, though in this case modelling the probability of having been drunk (most comparable measure of alcohol consumption available in each survey). The results are presented

using the YPBAS control group, though similar results were found when using the alternative surveys when comparable data was available. The DiD here is statistically insignificant, indicating that a general change in risky behaviour was not the cause of the observed change in smoking consumption. Using the same framework, DiD coefficients were estimated with a binary dependent variable indicating whether an individual regularly ate vegetables as a measure of general healthy behaviours, and again all DiD coefficients were insignificantly different from zero. Finally, all smoking models were rerun over a placebo time period (2002 to 2006 HBSC and 2003 to 2007 YPBAS) to test the common trend assumption, and again all DiD coefficients were insignificant different from zero.[10]

*****TABLE III ABOUT HERE**

Discussion

The results of the DiD analysis are strongly in favour of the use of MLAs to reduce smoking prevalence among adolescents. Several sensitivity checks support this finding. There are, however, limitations of the analysis that should be recognised. A year before the MLA increase, a complete ban on tobacco advertising in the print media was introduced in Ireland (see Currie and Clancy (2010) for a review of tobacco policy in Ireland), thereby introducing a potential source of bias in the results. While it is plausible that such a policy would affect smoking among adolescents in Ireland and not those in Northern Ireland, it seems implausible that such a policy would have a disproportionate effect on youth smoking rates in Ireland compared to adult smoking rates in Ireland. Nevertheless, it is not possible to isolate the impact of the two policy reforms in the DiD framework with available data, so this should be considered when interpreting results.

Another limitation of the study is the potential for omitted variable bias. Each covariate included in the analysis must be present and identically measured in each wave of each survey used. Unfortunately, covariates often associated with smoking, such as educational performance, socioeconomic status, or family income, are not available in each wave of each dataset, and therefore cannot be included as covariates in the analysis. The methodology employed in this analysis should help to negate possible biases due to omitted variables. The DiD estimate will only be affected if the composition of either treatment or control group changed in terms of the omitted variable. While this is plausible when comparing across countries, it is less likely within a country. Similarly, the DiD framework cannot isolate the effect of changes in the price of tobacco over the time period. The price of tobacco increased by less in Northern Ireland than it did in Ireland during the time period analysed here, and so may have contributed to the results based on the HBSC and

[10] Often, the common trend assumption underlying the DiD framework is tested using a placebo timed period from before the policy period. In this case however, suitable data does not exist pre-1998 so that such a test is not possible. As well as supporting the common time trend assumption, the results from the placebo time period analysed here suggest that the increase in the MLA produced a level shift in the difference in smoking behaviour between adolescents in Ireland and Northern Ireland. The trend between the two groups was unaffected however, and continued to be affected by common forces in subsequent time periods.

YPBAS comparison; it is far less likely to have contributed to the comparison using individuals from the same country, thereby facing the same change in price.[11]

A third limitation is that, in some cases, the timing of the smoking information in treatment and control groups does not perfectly coincide. The robustness of results across multiple control groups and multiple sensitivity checks suggests data timing differences are not the cause of the patterns observed here.

So how do MLAs compare to other tobacco control policies in terms of reducing smoking prevalence among adolescents? In a direct comparison with tobacco taxes, Ahmad and Billimek (2007) argued that while MLAs can have positive long term effects on reducing adult smoking prevalence, large tax increases would have greater and faster health benefits. Ross and Chaloupka (2003) found that measuring teen responsiveness to prices is sensitive to whether actual average prices are used to measure responsiveness, or teen "perceived" price. They found that teen demand for cigarettes was particularly responsive to perceived price; price elasticities greater than unity found in response to increases in perceived price, supporting the use of tobacco taxes to control youth smoking. Sen and Wirjanto (2010) and DeCicca et al. (2008) were less hopeful about the use of tobacco taxes to reduce youth smoking. Using a negative shock to Canadian tobacco excises that was implemented in response to a growing black market for cigarettes, Sen and Wirjanto found evidence that even significant and discrete changes in taxes might have limited impacts on the initiation and persistence of youth smoking. Cross-province variation in smoking initiation was limited despite large differences in tobacco tax policy during the period of analysis. Using US micro-data largely from the 1990s, DeCicca et al. also found little evidence of responsiveness of youth smoking initiation and argued that it may be time to re-examine the consensus among health policy makers that youth smoking participation is highly price-responsive.

Levy et al. (2004) conducted a review of evidence on the impact of a range of different tobacco control policies. They found that while policies such as higher taxes, clean air laws, media campaigns and advertising bans can all have positive impacts on reducing smoking, the most successful campaigns have implemented a combination of tobacco control policies. Studies by Altman et al. (1999), Lantz et al. (2000) and Levy and Friend (2002) came to the same conclusions. On this basis, while the results of this analysis strongly support the continued used of MLAs to combat youth smoking, the balance of evidence suggests they are most effective when used in combination with, rather than instead of, other tobacco control policies.

Conclusion

Tobacco control policy has consistently included MLAs in a number of jurisdictions in recent times, with considerable interest being shown in further increases to as high as 21 or beyond. Despite this policy movement, there remains considerable debate about the effectiveness of such policy in reducing smoking rates among adolescents. This is at least in part driven by a lack of evidence at national level on the impact of MLAs.

[11] In fact, while the price of tobacco increased by just above 30 per cent in Ireland between 1998 and 2002 (Central Statistics Office of Ireland, Statbank, table CPM03), mean real income also increased by approximately 30 per cent (author analysis based on LIS) between 1998 and 2001. The real price of tobacco in Ireland therefore remained constant during the period of analysis.

This paper aims to fill that gap. Using the 2001 nationwide increase in the MLA from 16 to 18 in the Republic of Ireland, the analysis here provides evidence of a significant positive impact of the increase in the MLA on reducing smoking prevalence among 14 and 15 years olds in the Republic of Ireland. Similar results were found on the likelihood of ever having tried a cigarette. As far as I am aware, the analysis here represents the first systematic analysis of the impact a nationwide increase in an MLA on the likelihood of smoking, using identically aged adolescents as the control group. Further checks of results using young adults in the Republic of Ireland as a control group confirmed the results.

The evidence here is therefore strongly in support of continued use of MLAs as a policy measure to reduce smoking prevalence among adolescents. Tobacco control policy in Europe is lagging behind Canada and the US in that regard.

Acknowledgements

The author thanks ISSDA for providing access to the SLÁN data [accessed via the Irish Social Science Data Archive website, www.ucd.ie/issda], the Northern Ireland Statistics and Research Agency Central Survey Unit for providing access to YPBAS [accessed via the UK Data Archive], Prof. Saoirse Nic Gabhainn for facilitating access to the HBSC data through the HBSC Data Management Center at the University of Bergen, the CSO for providing access to the SILC data, and the ESRI for providing access to LII. The author thanks Brendan Walsh, Conor Keegan, Karina Doorley and Claire Keane for comments.

References

Ai, C. and E. C. Norton (2003), 'Interaction terms in logit and probit models', *Economics Letters*, 1: 123–129

Altman, D.G., Wheelis, A.Y., McFarlane, M., Lee, H-R. and Fortmann, S.P., (1999) The relationship between tobacco access and use among adolescents: a four community study, *Social Science and Medicine*, 6: 759-775

Apollonio, D. E., and Glantz, S. A. (2016). Minimum ages of legal access for tobacco in the United States from 1863 to 2015. *American journal of public health*, 106(7), 1200-1207.

DeCicca, P., Kenkel, D., Mathios, A., Shin, Y.-J. and Lim, J.-Y. (2008), Youth smoking, cigarette prices, and anti-smoking sentiment. *Health Economics*, 17: 733–749

DiFranza, J.R., (2012) Which interventions against the sale of tobacco to minors can be expected to reduce smoking? *Tobacco Control,* 21:436-442

Fidler, J. A., and West, R. (2010). Changes in smoking prevalence in 16–17-year-old versus older adults following a rise in legal age of sale: findings from an English population study. *Addiction*, 11: 1984-1988.

Forster, J. L., Murray, D. M., Wolfson, M., Blaine, T. M., Wagenaar, A. C., and Hennrikus, D. J. (1998). The effects of community policies to reduce youth access to tobacco. *American Journal of Public Health*, 8: 1193-1198.

Katzman, B., Markowitz, S. and McGeary, K. A. (2007), An empirical investigation of the social market for cigarettes. *Health Economics,* 16: 1025–1039

Lantz, P. M., Jacobson, P. D., Warner, K. E., Wasserman, J., Pollack, H. A., Berson, J., and Ahlstrom, A. (2000). Investing in youth tobacco control: a review of smoking prevention and control strategies. *Tobacco control*, 1: 47-63.

Levy, D. T., Chaloupka, F., and Gitchell, J. (2004). The effects of tobacco control policies on smoking rates: a tobacco control scorecard. *Journal of Public Health Management and Practice*, 4: 338-353.

Levy, D. T., and Friend, K. B. (2002). Strategies for reducing youth access to tobacco: A framework for understanding empirical findings on youth access policies. *Drugs: education, prevention and policy*, 3: 285-303.

Ling P.M., Landman A. and Glantz S.A. (2002) It is time to abandon youth access tobacco programmes *Tobacco Control* 11**:**3-6.

Millett, C., Lee, J. T., Gibbons, D. C., and Glantz, S. A (2011) Increasing the age for the legal purchase of tobacco in England: impacts on socio-economic disparities in youth smoking *Thorax*66**:**862-865

Ontario Tobacco Research Unit (2015) "Raising the Minimum Age for Access to Tobacco to 21" *OTRU Updates* March [available at https://tinyurl.com/yblfgwp7, accessed 2/8/17]

Puhani, P. A. (2012). The treatment effect, the cross difference, and the interaction term in nonlinear "difference-in-differences" models. *Economics Letters*, 1: 85-87.

Rigotti, N. A., DiFranza, J. R., Chang, Y., Tisdale, T., Kemp, B., and Singer, D. E. (1997). The effect of enforcing tobacco-sales laws on adolescents' access to tobacco and smoking behavior. *New England Journal of Medicine*, 15: 1044-1051.

Ross, H. and Chaloupka, F. J. (2003), The effect of cigarette prices on youth smoking. *Health Economics*, 12: 217–230.

Schneider, S.K., Buka SL, Dash, K,. Winickoff, J. and O'Donnell, L. (2016) Community reductions in youth smoking after raising the minimum tobacco sales age to 21 *Tobacco Control* 25**:**355-359

Schnohr, C. W., Kreiner, S., Rasmussen, M., Due, P., Currie, C., and Diderichsen, F. (2008). The role of national policies intended to regulate adolescent smoking in explaining the prevalence of daily smoking: a study of adolescents from 27 European countries. *Addiction*, 5: 824-831.

Sen, A. and Wirjanto, T. (2010), Estimating the impacts of cigarette taxes on youth smoking participation, initiation, and persistence: empirical evidence from Canada. *Health Economics*, 19: 1264–1280

Tobacco-Free Policy Review Group (2000) *Towards a Tobacco Free Society* Report of the Tobacco Free Policy Review Group: Department of Health

Tutt, D., Bauer, L., and DiFranza, J. (2009). Restricting the retail supply of tobacco to minors. *Journal of public health policy*, 1:68-82.

U.S. Department of Health and Human Services. (2012) *Preventing Tobacco Use Among Youth and Young Adults: A Report of the Surgeon General.* Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health

Appendix

Table A1 : Summary Statistics of Covariates used in Econometric Analysis – HBSC and YPBAS

	Control Period		Treatment Period	
	HBSC	**YPBAS**	**HBSC**	**YPBAS**
age [mean]	14.5	14.5	14.5	14.5
Male	50.3	56.4	42.0	53.7
Like School				
I like it a lot	21.8	20.2	21.3	23.1
I like it a bit	48.2	50.0	46.2	50.2
I don't like it very much	19.5	19.6	19.8	17.8
I don`t like it at all	10.5	10.3	12.7	9.0
Been Drunk				
Never	64.9	59.2	67.6	61.4
1-3 Times	22.4	23.6	21.7	24.2
4+ Times	12.8	17.2	10.7	14.3
Physical Activity (times per week)				
Never	4.0	14.6	3.9	22.4
1-3 Times	47.0	45.4	33.4	42.1
4+ Times	49.0	40.0	62.7	35.4
Eat Vegatables (base= Rarely, Never)	87.3	81.1	86.1	80.1
Eat Fruit (base= Rarely, Never)	91.5	82.5	90.6	88.7
On a Diet				
No	67.2	61.1	61.8	61.4
No, but need to lose weight	24.0	25.7	23.4	27.5
Yes	8.8	13.2	14.8	11.1
Do you find it easy to talk to your Father?				
Don't have/see this person	5.1	7.9	5.7	7.8
Easy, very easy	41.7	59.4	49.7	60.2
diff, very diff	53.3	32.7	44.6	32.0
Do you find it easy to talk to your Mother?				
Don't have/see this person	1.5	2.6	2.7	2.9
Easy, very easy	70.6	82.0	74.4	80.8
diff, very diff	27.9	15.5	22.9	16.3
Do you find it easy to talk to your				

Elder Brother?				
Don't have/see this person	48.1	51.2	52.6	52.3
Easy, very easy	24.6	28.3	26.5	29.7
diff, very diff	27.3	20.5	20.9	18.0
Do you find it easy to talk to your Elder Sister?				
Don't have/see this person	47.1	50.2	55.0	52.3
Easy, very easy	34.0	35.8	32.5	36.5
diff, very diff	18.9	14.0	12.5	11.3
How many Close Friends do you have?				
3+	75.6	71.4	94.7	73.1
1,2	21.3	15.2	4.1	16.0
0	1.9	1.8	0.7	1.3
How pressured do you feel by the schoolwork you have to do?				
not at all	17.0	12.1	19.6	14.7
A little	43.9	44.3	37.6	47.6
Some	21.3	27.6	23.8	26.4
A lot	16.0	15.8	17.4	11.1

Table A2 : Summary Statistics of Covariates used in Econometric Analysis – HBSC and SLÁN

	Control Period		Treatment Period	
	HBSC	**SLÁN**	**HBSC**	**SLÁN**
Age	14.5	22.0	14.5	22.9
Male	50.3	49.3	42.0	41.8
Stress/Pressure	81.3	36.8	78.8	35.2
Consumes Alcohol	35.1	94.4	32.4	95.1

The measure of stress/pressure here is constructed as follows. In the HBSC, respondents are asked "How pressured do you feel by the schoolwork you have to do?", and can answer any of "Not at all", "A little", "Some" or "A lot". A binary variable is created which is equal to one if a respondent answers anything other than "Not at all". In SLÁN, respondents are asked "I think my own health would be better if I had…" and are given a list of possible answers that includes "less stress". A comparable binary variable is set equal to one for any respondent that answers "less stress".

The indicator for "consumes alcohol" is simply an indicator for any HBSC respondent that has been drunk at least once, and any SLÁN respondent that answers that they have ever consumed more than "sips or tastes" of alcohol.

The comparability of these constructed variables across surveys is debatable; results presented in the paper are insensitive to their inclusion.

Only age and gender are controlled for when using the LIS, or LIS/SILC control groups. In each case, approximately 50 per cent of each control group is male, and the mean age varies as expected with the maximum age cut-off imposed.

Figure A1: Map of Republic of Ireland and Northern Ireland.

Tables

Table I: Data Sources enabling DiD Identification Strategy

		Period	
		Control	*Treatment*
Group	*Treatment*	HBSC 1998	HBSC 2002
	Control	1. YPBAS 2000 2. SLÁN 1998 3. LIS 1998	1. YPBAS 2003 2. SLÁN 2002 3a. LIS 2001 3b. SILC 2003

Table II: Difference-in-Difference estimation, YPBAS Control Group

	Smoke at least one a week	Smoke at all	Ever Tried Smoking
dT	0.006	0.004	-0.030**
	(0.009)	(0.010)	(0.012)
dG	0.073***	0.122***	0.184***
	(0.009)	(0.010)	(0.013)
DiD (dT*dG**)**	**-0.052*** **	**-0.081*** **	**-0.097*** **
	(0.014)	**(0.015)**	**(0.018)**
Observations	*9,293*	*9,293*	*9,293*
R-squared	*0.225*	*0.244*	*0.273*

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table III: Difference-in-Difference estimation, YPBAS Control Group, Robustness Tests

				Placebo Time Period		
	Been drunk at least once	Been drunk > 3 times	Eats Veg.	Regular Smoker	Regular or Occasional Smoker	Ever Tried Smoking
DiD (dT*dG)	-0.032	-0.004	-0.010	0.012	0.020	0.020
	(0.020)	(0.014)	(0.016)	(0.014)	(0.015)	(0.018)
Obs.	9,293	9,293	9,293	8,892	8,892	8,892
R-sq.	0.126	0.087	0.037	0.233	0.259	0.338

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Figures

Figure 1: Smoking Prevalence

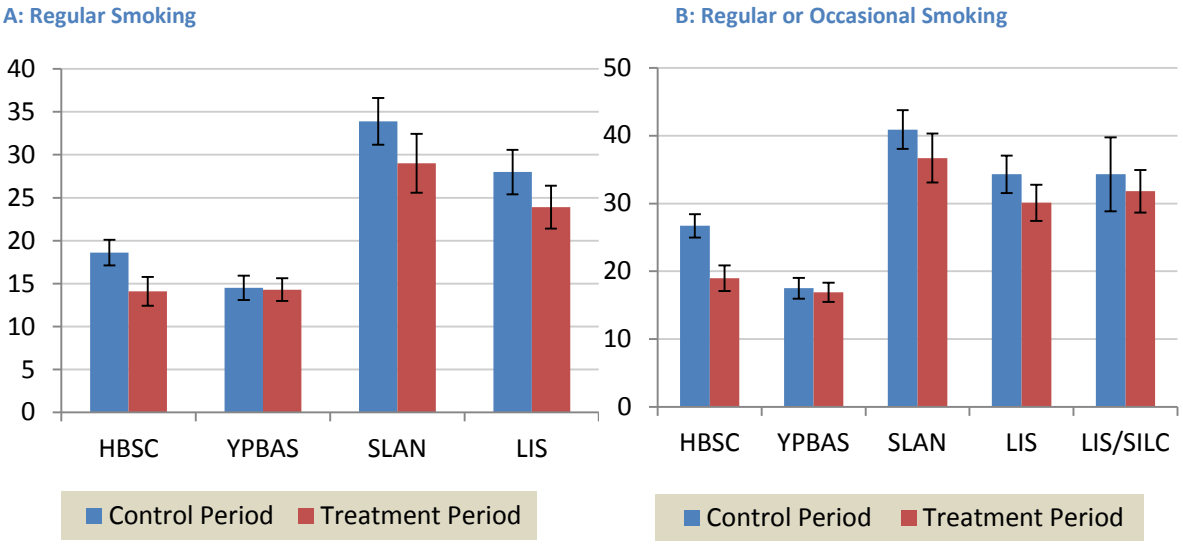


Table Notes: Capped Bars show 95% confidence Interval

Figure 2: Proportion of Group who have Ever Tried Smoking

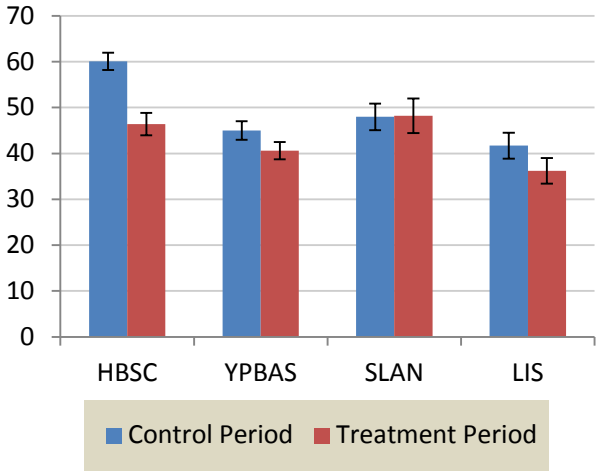
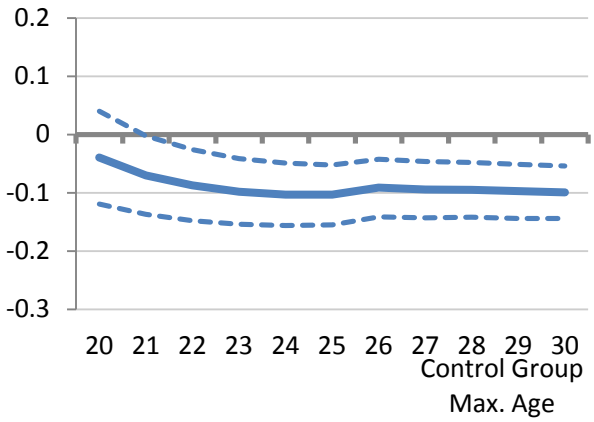


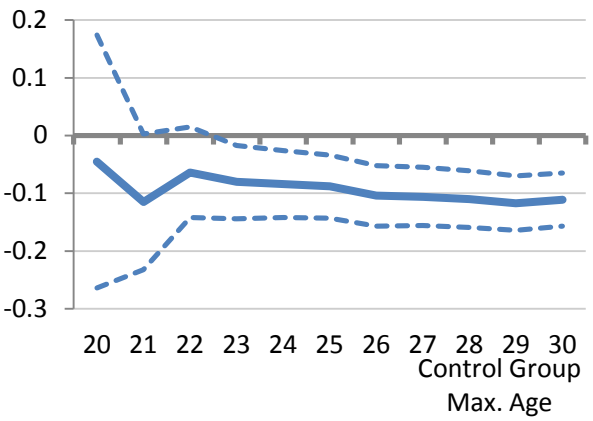
Table Notes: Capped Bars show 95% confidence Interval

Figure 3: DiD Coefficient with young adults as Control Group

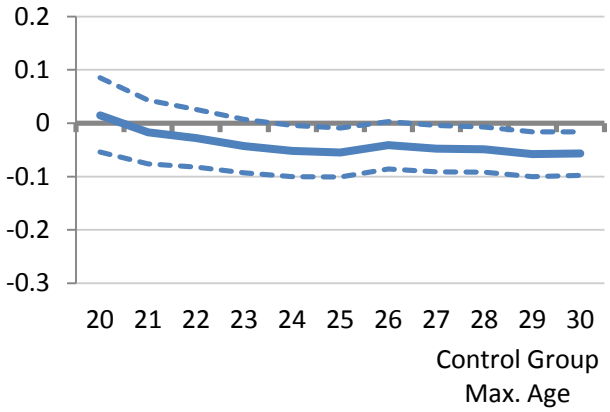
A: Ever Smoked, LII Control Group



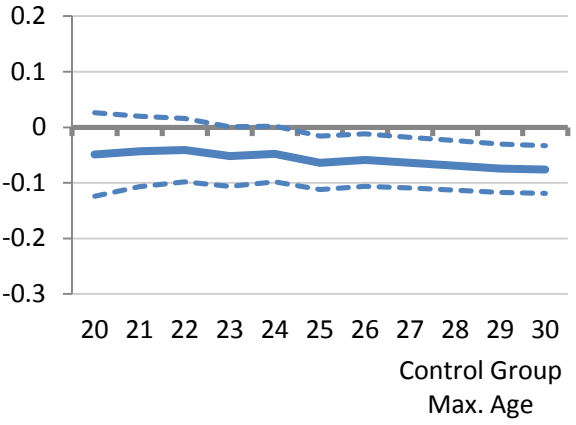
B: Ever Smoked, SLÁN Control Group



C: Current Smoking at all, LII Control Group



D: Current Smoking at all, LII/SILC Control Group



E: Current Smoking at all, SLÁN Control Group

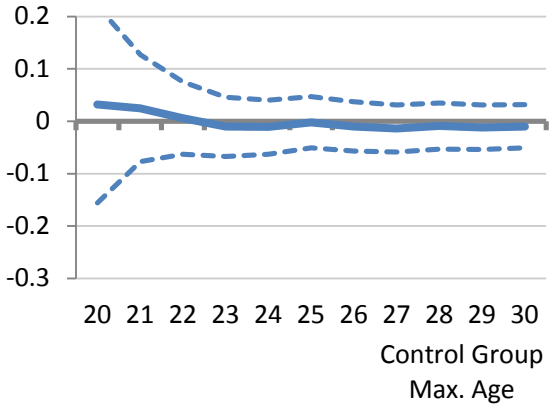


Figure Notes: Dashed lines indicate 95% confidence intervals.

Year	Number	Title/Author(s)
2017		
	571	The impact of investment in innovation on productivity: firm level evidence from Ireland *Mattia Di Ubaldo and Iulia Siedschlag*
	570	The value of tourist angling: a travel cost method estimation of demand for two destination salmon rivers in Ireland *Gianluca Grilli, John Curtis, Stephen Hynes and Gavin Landgraf*
	569	Advertising and investment spillovers in the diffusion of residential energy efficiency renovations *Matthew Collins and John Curtis*
	568	Working at a different level? Curriculum differentiation in Irish lower secondary education *Emer Smyth*
	567	Identifying rent pressures in your neighbourhood: a new model of Irish regional rent indicators *Martina Lawless, Kieran McQuinn and John R. Walsh*
	566	Who pays for renewables? Increasing renewable subsidisation due to increased datacentre demand in Ireland *Muireann Á. Lynch and Mel T. Devine*
	565	Can tenants afford to care? Investigating the willingness-to-pay for improved energy efficiency of rental tenants and returns to investment for landlords *Matthew Collins and John Curtis*
	564	Female participation increases and gender segregation *Claire Keane, Helen Russell and Emer Smyth*
	563	Pike (Esox lucius) stock management in designated brown trout (Salmo trutta) fisheries: Anglers' preferences *John Curtis*
	562	Financial incentives for residential energy efficiency investments in Ireland: Should the status quo be maintained? *Matthew Collins, Seraphim Dempsey and John Curtis*
	561	Does a satisfied student make a satisfied worker? *Adele Whelan and Seamus McGuinness*

For earlier Working Papers see http://ww.esri.ie