

**Is Roll-Your-Own tobacco substitute for manufactured cigarettes - evidence from Ireland?**

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## **Abstract**

### **Background**

When tax policies increase tobacco prices some smokers may switch to smoking cheaper roll-your-own (RYO) tobacco. To reduce the harm from smoking, this substitution effect should be avoided. This study analyses whether RYO-tobacco is a substitute for manufactured cigarettes (MC) in Ireland, a country with relatively high price for both products.

### **Methods**

Data on duty-paid consumption of RYO-tobacco from 1978-2011 are used to estimate the demand by applying seemingly unrelated regression and error correction models. Covariates include prices of tobacco in Ireland and in the UK, income and a variable describing tobacco related health policies.

### **Results**

We failed to find evidence of RYO-tobacco being a substitute for MC due to price differences. However, an increase in incomes (1%) is associated with a reduction in the consumption of RYO-tobacco (-0.4%) which can be due to substitution towards MC in addition to quitting or cutting back. Also, an increase in the price of RYO-tobacco (1%) is associated with a reduction in its consumption (1%).

### **Conclusions**

Increasing prices via taxation is an effective way of reducing the consumption of RYO-tobacco but due to associations between RYO-tobacco smoking and lower incomes, these policies should be accompanied by measures aimed at helping smokers to quit.

## **Introduction**

The health risk from consuming tobacco products has been long demonstrated, and increasing taxes is considered to be one of the most effective ways of reducing tobacco demand and thus improving public health (1, 2). However, in addition to being responsive to price changes, the economic theory suggests that the demand for one good also depends on the availability and the price of a substitute good. If Roll-Your-Own (RYO) tobacco is a suitable and a cheaper alternative for manufactured cigarettes (MC), then price increases, aimed at reducing the overall demand, could instead lead to some smokers substituting to the cheaper RYO-tobacco. In that case the taxation policies should take into account the substitution effects and adjust the tax levels so that the price difference between the products would not incentivise switching to a cheaper alternative.

Currently all European member states tax RYO-tobacco at a lower rate compared to MC (3) although from the public health perspective there is no justification for RYO-tobacco being cheaper. Studies examining the content of RYO-tobacco have suggested that it contains as many toxins and carcinogens as MC, if not more (4-10). Furthermore, it has been found that smoking RYO-tobacco can contribute to a higher risk of various health problems compared to MC (11-14). However, studies surveying smokers of RYO-tobacco have found that there is a perception of RYO-tobacco being a healthier alternative to MC. For example, Young *et al.* (2012) report that in the UK 27% of RYO-tobacco smokers listed it being healthier as one of the reasons for choosing it (15).

This paper analyses whether in Ireland RYO-tobacco has been a substitute product to MC. Ireland, where the prevalence of daily smokers ranged from 25-29% of the adult (15+) population in the last decade, offers an interesting case for studying this relationship. First, the prices of all tobacco in general have been high in comparison to other European countries(16, 17). Secondly, when compared on a 'gram per gram' basis, the prices of RYO-tobacco and MC have been similar while the share of RYO-tobacco in the total duty paid tobacco consumption has been low, at around 2-5% (18-20). For these two reasons an *a priori* expectation is to find no substitution effects.

## **Methods**

To test the substitution we estimate the demand for RYO-tobacco (and MC) in Ireland using time series data from 1978-2011. The demand is measured by the domestic duty paid

consumption of RYO-tobacco and MC per capita (15+) in packs of 20 cigarette sticks. We assume that one RYO cigarette weighs 0.63g equalling to 20 and 40 cigarettes per 12.5 g and 25g packs of tobacco respectively, which are the quantities RYO-tobacco is sold in Ireland. The demand for both RYO-tobacco and MC is assumed to depend on the own-price, disposable income (per capita 15+), and the excise duty rate of respective tobacco type in the UK, acting as a proxy to control for the cross-border prices. The demand for RYO-tobacco is further assumed to depend on the relative price of MC (with respect to the price of RYO). The relative price is used instead of the actual price of MC because it is more likely to be the difference in prices motivating substitution, rather than the absolute price. Data and sources are explained in detail in the online supplement.

The models also include a tobacco related health policy trend variable (*tobacco control vbl*) combining the following events, each given an equal weight: a complete ban in press advertising and corporate sponsorship (enacted in 2000), prohibition of the use of words such as 'low tar', 'light', 'mild' and the introduction of health warning labels on packages of tobacco (70% of the external area of the pack) (2003), smoke-free work place legislation (2004), and prohibition of selling packs of less than 20 cigarettes (2007). We employ a combined measure instead of individual policy variables due to the small number of observations available for estimation. Additionally, we include a variable to control for the economic downturn from 2008 that caused a rapid drop in incomes (see Figure 2) (*d2008*). This variable equals to one for years 2008 and above and zero before.

The continuous data are transformed into natural logarithm which allows interpretation of the estimated coefficients directly as elasticities measuring the *per cent* change in the demand as a response to a *per cent* change in the covariates (e.g. price). The coefficients for tobacco control policy and economic downturn variables are interpreted as semi-elasticities measuring the *per cent* change in the demand as a response to a *unit* change in the covariate.

Substitution from MC to RYO-tobacco is tested via the sign and significance of the estimated coefficient for the relative price of MC. A positive and statistically significant coefficient indicates that RYO-tobacco can be considered as a substitute for MC, as the demand for RYO responds positively to an increase in the relative price of MC. A negative coefficient indicates that the two tobacco products are complements, as a price increase in one is associated with a reduction in the demand of the other.

Three common tobacco demand models are applied where the first, a static demand model, makes no allowance for the addictive nature of tobacco (long-run model). Second, the myopic addiction demand model (MA), models addiction by including the consumption in the previous period (*cons.of RYO<sub>t-1</sub>*) (21), and lastly, the rational addiction demand model (RA) controls addiction by including past and also future consumption (*cons.of RYO<sub>t+1</sub>*) into the model (22).

The estimations are done using Iterated Seemingly Unrelated Regression (ITSUR) (23). This allows the estimation of individual demands for RYO and MC while allowing correlation between the disturbance terms. This is necessary as it is likely that the factors affecting the demand for one type of tobacco are closely related to the factors affecting the demand for another type, out of which some are unobservable (such as tastes and preferences) and will be present in the disturbance term. We test for serial correlation using Portmanteau *Q*-test in lags 1-2 and for normally distributed disturbance by Skewness and Kurtosis (*SK*-test). Breusch-Pagan test is used to indicate whether the disturbances of the two demand specifications are correlated, justifying the use of SUR model.

Because the data are aggregate time series which are likely to be non-stationary (meaning that the mean and the variance of the series changes over time), the regression results may be spurious, where the estimated coefficients appear significant and well explained only because of common trends affecting the data series, rather than indicating an existing long-term relationship between the series. However, if there exists a combination of the non-stationary series that itself is stationary (i.e. the disturbance term has a constant mean and variance over time), then it can be said that the series are cointegrated and a long-run equilibrium exists (represented by the static demand model).

To ensure our results are not spurious we test the order of stationarity of the series by Dickey Fuller Generalised Least Squares (DF-GLS) and Augmented Dickey Fuller (ADF) tests. We subsequently test for cointegration between the series using Engle-Granger two-step method (24). If the series are found to be cointegrated an error correction model (ECM) is also estimated (see online supplement). All analyses are done using Stata 12.0 (25).

## **Results**

Figure 1 graphs the consumption of RYO-tobacco and the real price of RYO-tobacco and MC in Ireland. Consumption of RYO-tobacco fell from more than 5.7 packs per capita in 1978 to

2.3 packs by 2005 but increased again to 5.5 packs by 2011. The price series of MC and RYO-tobacco follow a similar pattern although the former has increased faster and is more expensive. For most of the series the consumption of RYO-tobacco is falling as the two prices increase. Because the price difference is largest in the end of the series, where consumption makes a sharp upward turn, it is possible that some of this increase is explained by substitution effect.

Figure 1 here

However, a significant feature of the Irish market has been rapidly changing incomes (26). Figure 2 illustrates that during periods of income growth in Ireland, the consumption of RYO-tobacco on average fell, but when incomes started to decline in 2008, the consumption rapidly increased. Due to the addictive nature of tobacco it is likely that some of these changes are due to switching between RYO-tobacco and MC in addition to quitting or picking up the habit.

Figure 2 here

Table 1 presents the results for the three alternative tobacco demand models for RYO-tobacco (the online supplement table S2 presents the results of demand models for MC) and the results of an Engle-Granger ECM model. The latter is estimated as tests confirmed the non-stationarity of the series and the presence of cointegrating (long-run equilibrium) relationship in the series (see table S1 in online supplement for the test results).

Table 1 here

The rational addiction model [3] does not fit the data well as the lead consumption is not significant at conventional levels and there is significant serial correlation in the second lag ( $p=0.035$ ). Although the myopic addiction model [2] fits better, as lagged consumption is highly significant and positive as expected, there is also serial correlation in the disturbance term (lag 1,  $p=0.039$ ).

The static demand model [1] and Engle-Granger long- and short-run models [4-5] do not suffer from serial correlation although in models [1] and [4] *SK*-test rejects the assumption of normally distributed disturbance term. However, we consider this a smaller problem compared to serial correlation, which biases the variance estimator (27).

While the Engle-Granger ECM [5] shows the short-run dynamics between the series, column [4] represents the long-run equilibrium relationship. The difference between [4] and [1] is that in the former model the disposable income is in differenced form as the Engle-Granger approach requires the same order of stationarity for all the series).

The ECM [5] presents the short-run relationships and, as expected, has smaller coefficients (with the exception of disposable income) compared to the long-run and the static model (over time consumers adjust and are more responsive to changes). The error correction term ( $\hat{e}_{t-1}$ ) is highly significant and indicates that 80% of the adjustment towards the long-run equilibrium happens in one time period. Because this model is estimated with the data in differences we do not interpret the coefficients as these refer to growth rates and are of less interest although these do confirm the sign of the main variables of interest such as both prices and disposable income).

Regardless of the model choice, the relative price of MC has a highly insignificant coefficient suggesting that there are no associations between the consumption of RYO-tobacco and the relative price of MC. Hence we fail to find any evidence of substitution effects due to price differential.

However, the static model [1] indicates that an increase in disposable income by 1% in the long-run is associated with a reduction of RYO-tobacco consumption by 0.43%. This implies that RYO-tobacco is an inferior good, the consumption of which falls as incomes grow and *vice versa*. In the Engle-Granger long-run model [4] the disposable income has a positive but non-significant coefficient at conventional levels (due to differencing, its coefficient technically refers to an impact of increased growth rate of incomes on RYO-tobacco consumption).

The coefficient for *d2008* is positive and highly significant, showing that after controlling for changes in prices and income, the economic crisis that began in 2008 is associated with an increase in RYO-tobacco consumption (57-73% according to [1] and [4]). The coefficient for the own-price in [1] and [4] suggest that a 1% increase in the price of RYO-tobacco is approximately associated with a 1% decrease in its consumption.

RYO-tobacco in the UK appears as a substitute as a 1% increase in the price of RYO-tobacco in the UK is associated with an increases in consumption by 0.7-1.2% in Ireland (in model

[4] this coefficient is significant only at 10% level). The tobacco control variable is not significant at conventional levels in any of the models.

## **Discussion**

### *Main finding of this study*

This study tested whether RYO-tobacco is a substitute for MC in Ireland. The demand models applied provided no evidence of such association arising from price differential between the two products. However, the models suggest that RYO-tobacco is an inferior good as consumption reduces when disposable income increases. The economic crisis, which began in 2008, is associated with a significant increase in RYO-tobacco consumption. We also estimate that the consumption of RYO-tobacco decreases by approximately 1% in the long-run if the price of RYO-tobacco increases by 1%.

### *What is already known on this topic*

There are a limited number of studies examining the substitution between the two types of tobacco products. Two studies have found RYO-tobacco to be a substitute for MC in Germany and Finland (28, 29). A report from the UK has also provided some evidence of this (30). A recent report (2012) of tobacco demand analyses from Europe confirms the previous finding from Finland but fails to find substitution effects using data from Holland (31). Differences in the findings could be due to the price difference being larger in these countries (e.g. based on the figure presented in the German study, the real price of MC appears nearly 3 times higher compared to Ireland where it is less than 2). Also there could be systematic differences in the habits and preferences of the smokers.

The study of tobacco demand in Europe also estimates the association between incomes and RYO-tobacco smoking and finds, similarly to this study, that increases in incomes are associated with less consumption of RYO-tobacco in Finland and Holland (31). The importance of this relationship has also been reported in survey studies of RYO-tobacco-smokers. A Canadian study finds that lower income smokers were more likely to smoke RYO cigarettes compared to smokers with high income (32). The ITC 4-country studies find that in the UK, the US, Australia and Canada, smokers of RYO-tobacco are on average more likely to be in the low or moderate income group compared to MC smokers (15, 33). Equally, in New Zealand, smoking RYO-tobacco is primarily associated to higher deprivation levels (34).



### *What this study adds*

This study adds to the little evidence that exists on the demand for RYO-tobacco and more specifically the issue of substitutability between RYO-tobacco and manufactured cigarettes. The results indicate that *ceteris paribus* increasing the price of RYO-tobacco is an effective policy for reducing consumption. Although we found no evidence of substitution driven by the price differential between the two products, the negative association between RYO-tobacco consumption and disposable income implies that some substitution between the two products due to changes in income level is likely. We conclude this as it is unlikely that changes in consumption, after changes in incomes, happen only due to quitting or cutting back smoking.

Because RYO-tobacco smokers have also been found to be poorer than smokers of MC and more addicted (32, 33, 35), the findings of this study imply that simply increasing prices (especially in the negative economic climate) could push RYO-tobacco smokers further towards deprivation. It could also give more incentives for consuming illegal tobacco, which is likely to be a substitute for legal tobacco products. Thus, it is important that tax increases to reduce tobacco consumption are accompanied by other policy measures that help people to overcome their addiction and reduce the availability of illegal tobacco.

Another issue to address here is the weight of the RYO-cigarette. Because smokers can alter the weight of the cigarette, they can counteract increases in prices and adjust the consumption to changes in income (assuming that the satisfaction from the cigarette does not change with small changes in the quantity of tobacco used). Therefore, it is likely that this type of tobacco is attractive in the negative economic climate. In the literature the weight of RYO-cigarette was found to vary from 0.4g to 0.8g per stick (7, 28, 30, 36-42). Clearly, the less tobacco is rolled into a cigarette, the cheaper it will become relative to MC.

Although trends in market shares suggest that consumption of RYO-tobacco in Ireland is considerably smaller compared to MC, studies from other countries report growing prevalence and therefore emphasise the importance of the issue of substitution. In the UK 37% of male smokers and 21% of female smokers in 2009 reported mainly smoking RYO-tobacco compared to 25% and 8% in 1998 (43). Similarly, a recent article by Young *et al.* showed that the percentage of smokers predominantly smoking RYO tobacco steadily increased in the US, the UK and Australia from 2002 to 2008, with the largest absolute increases found in the UK (15). Two recent Eurobarometer Surveys on Tobacco use in

Europe (2009 and 2012) show that the percentage of daily RYO smokers has grown from 15% to 20%.

#### *Limitations of this study*

This study used annual aggregate data on duty paid purchases of tobacco products which places three restrictions. First, it does not allow the demand by different social classes and other factors such as, gender, sex and age, to be analysed, which may play an important role. Secondly, due to lack of time series data we cannot control for changes in smoking prevalence, quitting rates and rates of picking up smoking. Equally, we cannot control for consumption of smuggled or illegal tobacco, all of which might be possible using individual level survey data.

Lastly, the number of observations is small, restricting the choice of models. Specifically, the small sample size does not allow the use of time series models to test for, and estimate, more than one cointegrating relationship. As the household budget data are available at 5-year intervals only and there are no sufficient data from other surveys, aggregate time series remain the only available option.

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**Table 1** Demand for RYO-tobacco in Ireland (1978-2011)

<i>ln(consumption of RYO)</i>	Static <sup>a</sup> [1]	Myopic Addiction <sup>a</sup> [2]	Rational addiction <sup>a</sup> [3]	Engel- Granger long-run <sup>b</sup> [4]	Engel- Granger ECM <sup>c</sup> [5]
<i>ln(price of RYO)</i>	-1.013*** (0.244)	-0.453* (0.257)	-0.219 (0.294)	-0.946** (0.363)	-0.507 (0.318)
<i>ln(relative price of MC)</i>	-0.430 (0.674)	0.074 (0.648)	0.100 (0.630)	-0.899 (0.955)	-0.038 (0.587)
<i>ln(disposable income)</i>	-0.434** (0.176)	-0.250 (0.159)	-0.200 (0.165)	0.196 (0.938)	-0.832** (0.352)
<i>ln(price of RYO in the UK)</i>	1.168*** (0.324)	0.525 (0.337)	0.320 (0.357)	0.684* (0.385)	0.389** (0.171)
<i>Tobacco control vbl.</i>	0.038 (0.025)	0.012 (0.023)	0.013 (0.024)	0.001 (0.033)	-0.011 (0.008)
<i>d2008</i>	0.569*** (0.140)	0.342** (0.140)	0.102 (0.208)	0.734*** (0.194)	0.227*** (0.053)
<i>ln(cons. of RYO)<sub>t-1</sub></i>		0.478*** (0.127)	0.414*** (0.131)		
<i>ln(cons. of RYO)<sub>t+1</sub></i>			0.318 (0.214)		
<i>EC (<math>\hat{e}_{t-1}</math>)</i>					-0.814*** (0.104)
<i>Constant</i>	6.240*** (1.614)	3.345** (1.573)	2.364 (1.667)	2.282*** (0.279)	0.001 (0.023)
Adjusted $R^2$	0.732	0.786	0.776	0.561	0.781
<i>Portmanteau Q</i> (1 lag) <sup>d</sup>	0.719	0.039	0.100	0.609	0.369
<i>Portmanteau Q</i> (2 lags) <sup>d</sup>	0.920	0.115	0.035	0.878	0.571
<i>SK test</i> <sup>e,d</sup>	0.008	0.090	0.035	0.000	0.984
<i>Breusch-Pagan test</i> <sup>d</sup>	0.029	0.073	0.099	n/a	n/a

Notes: standard errors in parentheses; \*\*\* $p < 0.001$  \*\* $p < 0.05$  \* $p < 0.1$ ;

<sup>a</sup> Estimations by ITSUR; *Breusch-Pagan* test confirms that at 10% level that the disturbance terms of RYO-tobacco and MC demand models in [1]-[3] are correlated and using SUR estimation model accounts for this correlation.

<sup>b</sup> Because Engle-Granger approach requires all the series to be first order stationary (i.e. require differencing once to make stationary), the long-run demand model is estimated with disposable income in first differenced form as it was found to be second order stationary (needed differencing twice to make stationary) (see online supplementary material)

<sup>c</sup> In the short-run model all variables are estimated in first differenced form apart from disposable income which is in second differenced form (stationary).

<sup>d</sup>  $p$ -values

<sup>e</sup> Skewness and Kurtosis test for normally distributed disturbance term

## **Figure headings**

**Fig. 1** Consumption (per capita 15+) and price of Roll-Your-Own (RYO) tobacco (12.5g packs) and price of manufactured cigarettes (MC) (pack of 20) in Ireland (1 MC = 0.63g of RYO-tobacco)

**Fig. 2** Consumption of Roll-Your-Own (RYO) tobacco (12.5g packs) and disposable income in per capita (15+) in Ireland