Supplementary on-line material

1. Data

RYO-tobacco consumption data were requested from the Office of the Revenue Commissioners on the quantities of rolling tobacco for which the duty is paid and which are intended for domestic purchases. The data in kg's are transformed into consumption of 12.5g packs of RYO-tobacco per capita (15+ older) (1). As we assume 1 MC = 0.63g of RYO tob, a 12.5g pack of RYO-tobacco would contain 20 cigarettes.

The annual average price of 12.5g pack of RYO-tobacco is calculated from the survey of cross-border prices for 2007-2011 (2) and an is extrapolated back to 1978 by using the consumer price index (CPI) for 'other' tobacco products, requested from the Central Statistics Office of Ireland (CSO). The real price of RYO-tobacco is calculated by deflating the nominal series by the overall CPI, excluding tobacco (base year 2006) (3).

The annual average price of a pack of MC is calculated based on the monthly national average price of a pack of 20 filter tipped cigarettes for 1983 to 2011. These are extrapolated back to 1978 by using the CPI sub-index for cigarettes (both requested from the CSO). The prices in Irish Pounds are converted into Euros by using the official exchange rate and are then deflated by the CPI of all items, excluding tobacco (base year 2006). The relative price of MC is found by dividing the real price of MC by the real price of RYO-tobacco (12.5g pack). The gross disposable national income is transformed to per capita terms (15+) and is deflated using the CPI of all items (base year 2006) (4).

The excise duty rates for the RYO-tobacco in the UK are calculated calculated on weighted basis depending on how many months a particular rate was in place (5). The excise duty rates up to 2000 were converted into Irish Pounds, and the full series were converted to Euros using the official exchange rate of Irish Pound to Euro for the series up to 2000 and using the annual exchange rates for the remaining series (6). Finally the excise rates were deflated by using the Irish CPI of all items, excluding tobacco (base year 2006).

2. Test for stationarity and cointegration and Engle-Granger error correction model

Table S1 shows the results of Dickey Fuller Generalised Least Square (DF-GLS) and Augmented Dickey Fuller (ADF) tests for the order of stationarity in the series used in the analysis. In all the series (except for the price of MC), tests failed to reject non-stationarity in

the level of the series (series as they are). Subsequently, non-stationarity is tested in first-differenced series (denoted by Δ) where the previous period value (t-1) of the series is subtracted from the current value of the series (t). In all the series, apart from disposable income, non-stationarity is now rejected at least at 5% level (at 10% level for the series of price of RYO-tobacco in the UK) meaning that the series are first order stationary.

Disposable income series are second order stationary as non-stationarity is rejected only after second difference is applied. Although non-stationarity of the price of MC series is rejected without differencing, the autocorrelation plot of the series clearly indicates that the series are non-stationary and hence we proceed in the analysis with the assumption that this series also requires differencing (once) to be stationary (autocorrelation plots available upon request).

Table S1 DF-GLS and ADF test for stationarity of the series (H_0: series are non-stationary)

Variable	**Lag** [a]	**Deterministic terms**	***Tau* statistic**	**5% CV**
ln(Consumption of RYO)	4	trend	-1.32	-3.08
Δ *ln(Consumption of RYO)*	5	no trend	-2.56	-2.28
ln(Price of RYO)	1	trend	-2.97	-3.40
Δ *ln(Price of RYO)*	1	no trend	-4.88	-2.48
ln(Relative price of MC)	1	trend	-2.02	-3.40
Δ *ln (Relative price of MC)*	1	no trend	-2.80	-2.48
ln(Disposable income)	1	trend	-1.86	-3.40
Δ *ln(Disposable income)*	1	no trend	-1.53	-2.48
ΔΔ *ln(Disposable income)*	0	no constant, no trend [b]	-5.48	-1.95
ln(Price of RYO in the UK)	1	trend	-2.12	-3.40
Δ *ln(Price of RYO in the UK)*[c]	1	no trend	-2.40	-2.48
ln(Consumption of MC)	1	trend	-1.53	-3.40
Δ *ln(Consumption of MC)*	1	no trend	-3.32	-2.48
ln(Price of MC)	1	trend	-3.75	-3.40
Δ *ln(Price of MC)*	1	no trend	-4.24	-2.48
ln(Price of MC in the UK)	1	trend	-2.40	-3.40
Δ *ln(Price of MC in the UK)*	1	no trend	-2.72	-2.48

Notes: [a] selected based on the minimum Schwarz Information Criterion (SIC)
[b] denotes ADF test
[c] non-stationarity is rejected at 10% level

Cointegrating relationship, if exists, shows the long-run equilibrium between the series and is generally estimated by applying an error correction model (ECM) to adjust for short-run deviations from the long-run equilibrium. One of the most common tests for cointegration is

the Engle-Granger two-step test (7) where in the first step the following long-run relationship is estimated (assuming two series for simplicity):

$$y_t = \beta_0 + \beta_1 x_t + e_t \qquad \{1\}$$

If the variables y_t and x_t are cointegrated there exists a linear combination of the two that is stationary. A convenient way of testing this is to test the stationarity of the estimated disturbance from the long-run relationship, $\hat{e}_t$ which is the second step. Thus, series y_t and x_t are cointegrated if the estimated disturbance $\hat{e}_t$ is a stationary process. In this case an ECM can be estimated in the following form (5):

$$\Delta y_t = \alpha_0 + \beta_1 \Delta x_t + \gamma \hat{e}_{t-1} + \varepsilon_t \qquad \{2\}$$

Where:

Δ denotes differenced series

$\hat{e}_{t-1}$ is the error correction term (deviation from long-run equilibrium in period (*t*-1))

ε_t is uncorrelated with zero mean and finite variance.

The above ECM in {2} represents the short-run model where the error correction term incorporates the long-run information. The magnitude of γ shows the deviation from the long-run equilibrium, or the 'speed of adjustment'. Values close to one indicate that most of the adjustment happens within one time period.

In this study we first estimate the static demand model in {1} and continue to test the stationarity of its disturbance term. Because the test requires all the series to be first order stationary (i.e. require differencing once to make stationary), the static 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) (results in Table 1 [4]).

To test the stationarity of the disturbance term we use the ADF test with McKinnon critical values as we have more than one series in the explanatory model. With *n*=5 (for RYO) and *n*=4 (for MC) (number of non-stationary series), and no lags included, the test rejects non-stationarity of the disturbance term for both RYO-tobacco (*tau* statistic is -5.89) and MC (*tau* statistic -4.57) (5% critical values are -4.84 and -4.47 for RYO-tobacco and MC models respectively). These results allow concluding that both demand models RYO-tobacco and MC have cointegrated series and thus require an ECM model (Table 1[5] and Table S2).

Table S2 Demand for manufactured cigarettes (MC) in Ireland 1978-2011

ln(consumption of MC)	**Static** [a]	**Myopic addiction** [a]	**Rational addiction** [a]	**Engle-Granger long-run** [b]	**Engle-Granger ECM** [c]
ln(price of MC)	-0.958***	-0.549***	-0.594***	-0.921***	-0.513***
	(0.070)	(0.085)	(0.149)	(0.102)	(0.139)
ln(disposable income)	0.183**	0.112**	0.123*	-0.182	0.026
	(0.070)	(0.053)	(0.068)	(0.316)	(0.168)
ln(price of MC in the UK)	0.296***	0.187***	0.198**	0.424***	0.287***
	(0.072)	(0.057)	(0.078)	(0.062)	(0.067)
tobacco control vbl	-0.046***	-0.037***	-0.040***	-0.039***	-0.006
	(0.008)	(0.006)	(0.012)	(0.010)	(0.004)
d2008	0.016	0.020	0.022	-0.038	0.007
	(0.039)	(0.028)	(0.030)	(0.053)	(0.025)
$ln(consumption\ of\ MC)_{t-1}$		0.410***	0.401***		
		(0.069)	(0.083)		
$ln(consumption\ of\ MC)_{t+1}$			-0.047		
			(0.151)		
$EC(\hat{e}_{t-1})$					-0.845***
					(0.150)
Constant	4.196***	2.412***	2.624***	5.904***	-0.007
	(0.680)	(0.601)	(0.965)	(0.105)	(0.012)
Adjusted R^2	0.979	0.989	0.986	0.969	0.701
Portmanteau Q (1 lag)[d]	0.493	0.052	0.069	0.403	0.644
Portmanteau Q (2 lags)[d]	0.497	0.080	0.113	0.16	0.292
SK-test [e]	0.032	0.276	0.289	0.052	0.774

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

[a] Estimations by ITSUR

[b] Because Engle-Granger approach requires all the series to be first order stationary (i.e. require differencing once to make stationary), the long-run 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)

[c] In the short-run model all variables are estimated in first differenced form apart from disposable income which is now in second differenced form.

[d] Portmanteau *Q*-test for serial correlation in lags 1 and 2 (*p*-values)

[e] Skewness and Kurtosis test for normally distributed disturbance term (*p*-values)

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