Tobacco price elasticity in Serbia: using the micro data from Household Budget Survey and Deaton demand model

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Abstract: In this paper we use Deaton's (1988, 1977) demand model and Household Budget Survey (HBS) data for the years 2012 – 2016 to estimate the price elasticity for Serbia. Previous research has suggested that the price elasticity of tobacco products is typically negative and inelastic. The price elasticity of cigarettes is estimated at -0.45 and its statistical significance is confirmed via bootstrapping procedure, therefore confirming the previous findings. Estimated negative and inelastic cigarettes price elasticity for Serbia demonstrates that tobacco tax policy can be used effectively to reduce cigarette consumption and their harmful effects, while preserving or increasing the level of government revenue collected through taxes.

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1. Introduction

Tobacco expenditure represents a significant portion of the household budget, especially in the middle income countries (John, 2008), such as Serbia. In these countries, households' consumption responses to the price changes are typically more pronounced than in the developed countries (Chaloupka et al. 2000). Estimated price-elasticity of demand for cigarettes for developed countries ranges between -0.25 to –0.5, while in the low and middle income countries the estimates vary between -0.5 and -1. However, there are no reliable estimates of the price-elasticity of demand for cigarettes in Serbia, or in the Western Balkans region in general.

The cigarette prices' dynamics is under the impact of the excise policy, which is used both to reduce the smoking prevalence in the country and to increase budget revenues. These revenues can also be lower if the increase of the

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excises, and consequently the prices, creates lower demand for cigarettes. It is therefore important for the government to know the elasticity of household consumption to the prices changes.

Price elasticity can be estimated by using the macro-level time series approach, which relies on measures of price and consumption (and other control variables) per observation period. However, these models have been criticized for the lack a theoretical background and arbitrary choice of functional form and variables. In addition, time series are typically not long enough to produce reliable estimates (Deaton, 1997).

An alternative approach has its theoretical foundation in the consumer theory. One of the first models – Almost Ideal Demand System (AIDS model) for the estimation of price elasticity - was proposed by Deaton and Muellbauer (1980) and it relies on household budget data and regional price differences. However, the price information that matches the individual or household expenditure data on certain goods is frequently not available (McKelvey, 2011).

On the other hand, information from the household budget surveys typically contains both expenditure and quantity purchased of certain goods. Their ratio can then be used to create a unit value of a good, which is then used as a proxy for price. Although an imperfect proxy, mainly due to the fact that it reflects both quality and quantity of the purchased good (McKelvey, 2011), unit value has been extensively used and its value demonstrated.

Deaton (1988) demand model uses unit values as a proxy for price, spacial variation, and a structure imposed by a weak separability assumption accounting for the effect of good's quality. Basic idea of the model is that all households within a cluster (typically a small territory unit, such as municipality or village) face the same market price and that within-cluster variations in purchases depend only on total household expenditure and HH characteristics, while cross-cluster variations in purchase are due to genuine price variations, among other factors. The estimation of the model consists of three stages. In the first stage, the effects of total household expenditure and other household characteristics are by the means of regression analysis purged from the budget share of the consumption and unit value. In the second stage, cluster average values of budget share and unit values are used to estimate unit value elasticity of consumption. In the final, third stage, we use separability assumption to separate the effect of price elasticity from the quality effects contained in unit value elasticity.

In this paper we use Deaton's (1988) demand model and Household Budget Survey (HBS data) from 2012 to 2016 to estimate the elasticity of cigarettes demand in Serbia exploiting time and spatial price variation. Following this introduction the second section presents the Deaton's demand model in more detail, while the third section discusses the data used for the analysis and provides some stylized facts. We present the results of the analysis in the fourth section and the fifth section concludes the paper.

2. Econometric model and methods

Deaton's model

Deaton (1988) uses unit values of cigarettes as a proxy for price and a structure imposed by the weak separability assumption to impute the extent of the quality substitution in estimating the price elasticity. Deaton's model consists of two equations:

$$w_{hc} = \alpha^0 + \beta^0 lnx_{hc} + \gamma^0 . z_{hc} + \theta lnp_c + u_{ch}^0 \quad (1)$$

$$lnv_{hc} = \alpha^1 + \beta^1 lnx_{hc} + \gamma^1 . z_{hc} + \psi lnp_c + u_{hc}^1 \quad (2)$$

where indices *h* and *c* represent households and clusters respectively. The left-side variables in the model are w_{hc} – share of the household budget spent on cigarettes (in percentages) and v_{hc} – unit values. On the right side of both equations we have x_{hc} – total expenditures of the household *h* in cluster *c*, z_{hc} – other household characteristics, p_c – price of the cigarettes in cluster c, while u_{ch}^0 and u_{hc}^1 represent the error term. Since the prices are not observed, the parameters θ and ψ cannot be directly estimated from the equations (1) and (2). However, the assumption that the market prices do no vary within the cluster (hence the absence of the index h) enables consistent estimates of the remaining parameters by using cluster deviation-from-the-mean approach which cancels the effect of the prices from the equations as they do not vary within cluster.

In practice, the parameters are estimated by including dummy variables for each cluster[2] in the regression, which yields identical estimates as deviation-from-the-mean approach and is less computationally demanding (Frisch-Waugh, 1933).

[2] Since we are not interested in the size of the effect of each cluster, we use stata absorb (cluster) function for this estimation.

As unit values represent a ratio between expenditures and quantity of a good, their dynamic represents not only the changes of the prices of the cigarettes but also the changes in the choice of cigarettes quality (brands). When the cigarettes prices change, with the same budget, the household can decrease their consumption of the cigarettes and stay with the same brand or opt to buy less expensive brand and keep their consumption at the same level, which is referred to as quality shading.

Therefore, a change in consumption as a function of the unit value contains both the response of the household to the changes in prices, and possible quality shading. In the unit value equation (equation 2), coefficient β^1 represents "quality elasticity" or expenditure elasticity of quality, while ψ represents the changes in the unit value of cigarettes as a function of the changes in the prices. If there is no quality shading the value of ψ should be equal to one (as the change of the unit value would correspond to change of the price) and β^1 approximately equal to zero.

The estimation of the parameter θ, which represents the semi-elasticity of price is not possible as the price is not observed. However, the Deaton's model uses the fact that price is present in both equations in order to estimate the parameter. In the first step we re-write the equation (2) so the prices ($\ln p_c$) are on the left side of the equation, while unit values, household expenditure, other household characteristics and the error term are on the right side. We then substitute re-organized equation (2) for the price (lnp_c) in the equation (1) and obtain a linear relationship between the budget share as the dependent variable, and unit values and other variables as the independent variables:

$$w_{hc} = \alpha^2 + \beta^2 lnx_{hc} + \gamma^2 . z_{hc} + \hat{\phi} lnv_{hc} + u_{ch}^2 \qquad (3)$$

Estimated parameter $\hat{\phi}$ is a hybrid of price and quality elasticity and it can be shown to equal to $\psi^{-1}\theta$ (Deaton, 1990). These effects are later separated by introduction of the weak separability assumption. As mentioned previously, if there is no quality shading, the unit value changes represent the price changes, ψ equals one, and the coefficient $\hat{\phi}$ is the unbiased estimate of price semi-elasticity (θ). However, if the values of ψ is less than one (i.e. there is quality shading), $\hat{\phi}$ overestimates the parameter θ and needs to be corrected.

Estimation of the model

The estimation of the model is performed in three stages. In the first stage, equations (1) and (2) can be estimated by using the deviation-from-the-mean approach and cluster regression estimates. Therefore the parameters β^0,β^1,γ^0, γ^1 and the error terms in these equations are unbiased.

In the second stage, we use the estimates from the first stage and remove the effects of the total household expenditure and other household characteristics from the budget shares and the unit values:

$$\tilde{y}_{hc}^0 = w_{hc} - \tilde{\beta}^0 lnx_{hc} - \tilde{\gamma}^0 z_{hc} \quad (4)$$

$$\tilde{y}_{hc}^1 = lnv_{hc} - \tilde{\beta}^1 lnx_{hc} - \tilde{\gamma}^1 z_{hc} \quad (5).$$

The results of the second stage are then used to create cluster averages of budget shares and unit values

$$y_c^0 = \alpha^0 + \theta lnp_c + f_c + u_c^0 \quad (6)$$

$$y_c^1 = \alpha^1 + \psi lnp_c + u_c^1 \quad (7).$$

Variance and covariance of u_{hc}^1 and u_{hc}^0 from estimated residuals in equations (1) and (2) are estimated by $\hat{\sigma}^{00} = e_0'e_0/(n-k-C)$ $\hat{\sigma}^{11} = e_1'e_1/(n_1-k-C)$ $\hat{\sigma}^{01} = e_1'e_0/(n_1-k-C)$, where n is the total number of households, n_1 is the number of households which have purchased cigarettes, k is the number of explanatory variables; and e_1 and e_0 are the residuals from equations (1) and (2). If n_c is the number of all the households per cluster and n_c^+ is number of households with cigarette purchases the parameter ϕ from the equation (3) can then be estimated as

$$\hat{\phi} = \frac{\mathrm{cov}(\hat{y}_c^0, \hat{y}_c^1) - \hat{\sigma}^{01}/n_c}{\mathrm{var}(\hat{y}_c^1) - \hat{\sigma}^{11}/n_c^+} \quad (8)$$

In the third stage, we introduce the assumption on weak separability and the definition of the budget share as the product of quantity of cigarettes and unit value divided by the total expenditures. From there it can be shown (Deaton, 1990) that the parameter θ can be calculated as

$$\theta = \phi/[1 + (w-\phi)\frac{\beta^1}{\beta^0 + w(1-\beta^1)}] \quad (9)$$

where β^1 and β^0 are estimated from the equations (1) and (2), while *w* is the average value of the budget share. If β^1 (estimated unit value elasticity of expenditure) is close to zero there is no quality shading and price semi-elasticity represents an unbiased estimate of ϕ. If there is quality shading, θ has to be corrected downwards. Finally, since budget shares in the equation (1) are not in log form, the price elasticity of budget share equal θ/w. Since the budget share is unit value times quantity divided by total expenditure, the final formula for price elasticity of demand is (Deaton, 1997):

$$\epsilon_p = \left(\frac{\theta}{w}\right) - \psi \qquad (10).$$

Additionally, since in the equation (1) on the left hand side we have budget shares and not logarithm of quantity, parameter β^0 does not estimate the expenditure elasticity of demand. Instead, as the budget shares can be defined as the product of quantity and quality divided by total expenditure, i.e. w = q*v/x, we can arrive to an estimate of total expenditure elasticity by taking the log and the first derivative with respect to expenditure of this identity. We arrive to:

$$\frac{\partial lnw}{\partial lnx} = \frac{\partial lnq}{\partial lnx} + \frac{\partial lnv}{\partial lnx} - \frac{\partial lnx}{\partial lnx} \qquad (11)$$

where $\frac{\partial \mathrm{lnq}}{\partial \mathrm{lnx}}$ represents the total expenditure elasticity of demand, $\frac{\partial lnw}{\partial lnx}$ is the budget share elasticity which can be estimated from equation (1) as $\frac{\beta^0}{w}$, while $\frac{\partial lnv}{\partial lnx}$ is the elasticity of quality to expenditure from equation (2). After we rearrange the equation and replace the identities with estimates from equations (1) and (2) we estimate the total elasticity of expenditure as (Deaton, 1997):

$$\epsilon_x = 1 - \beta^1 + \left(\frac{\beta^0}{w}\right) \qquad (12).$$

We follow John (2008) and impose symmetry restrictions to increase the precision of the parameter estimates. Due to the calculation procedure, standard errors cannot be taken directly from the regression analyses. Instead we use boostrapping procedure with 1000 replications to arrive to standard error of the estimated price elasticity.

3. Data and stylized facts

In order to estimate the price elasticity of the cigarettes consumption we use the Household Budget Survey (HBS) data for years from 2012 to 2016. HBS is a annual survey, which provides detailed information on household consumption as well as on individual characteristics of the household members (SORS, 2016). Additionally, data contain information on the municipality and region in which the respondents live.

Unit values are calculated as a ratio of monthly household expenditure on cigarettes and the number of cigarette packs purchased by the household during a month. Therefore, the unit values are expressed in Serbian RSD per cigarette pack. On the other hand, we calculate budget share as a ratio of monthly household expenditure on cigarettes and the total monthly household expenditure. Both cigarette and total expenditure variables are deflated to their real values from 2012, by using Consumer Price Index [3].

Table 1 presents results of regression analyses exploring the time and regional variation of the real cigarettes unit values and budget shares. The results indicate that both unit values and budget shares show considerable time and regional variation.

Table 1: Regional and time variation of cigarettes unit values and budget shares

VARIABLES	Unit Value (per cigarette pack)		Cigarettes budget share (in %)	
Region Belgrade	Omitted			
Vojvodina	-12.400***	(0.733)	0.012***	(0.002)
West Serbia	-9.490***	(0.712)	0.016***	(0.002)
East Serbia	-10.832***	(0.759)	0.031***	(0.002)
Year 2012	Omitted			
2013	39.008***	(0.855)	0.011***	(0.002)
2014	64.301***	(0.797)	0.014***	(0.002)
2015	63.708***	(0.780)	0.012***	(0.002)
2016	78.569***	(0.792)	0.019***	(0.002)
Constant	133.383***	(0.768)	0.060***	(0.002)
Observations	10,033		10,033	
R-squared	0.543		0.042	

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Author's calculation based on the HBS data.

[3] Available online from the Statistical Office of the Republic of Serbia website http://www.stat.gov.rs/

The constant term in the unit value regression indicates that the average price for cigarette pack paid by the household in Belgrade in 2012 stood at about 133 RSD. Households in other regions typically pay lower prices of cigarettes, by about 10 RSD, while the average price of the cigarettes has been increasing throughout the period. On the other hand, the budget share regression indicates that the households in Belgrade in 2012 spent about 6% of their budget on cigarettes (conditional on having cigarettes expenses), with other regions spending on average between 1 and 3 percentage points more. The analysis also indicates that the budget share spent on cigarettes has increased over the years.

4. Results

Definition of clusters and the vector of covariates

For Serbia, we define clusters based on the information on municipalities and years, i.e. the cluster is defined as a municipality x in the year t. According to this definition we generate 763 clusters, which on average include about 74 households[4]. In total, there were 28,092 households in our sample. The first stage regression controlled for total expenditures (ln), as well as household size (ln), urban/rural status, age and gender composition of the household, as well as the mean and maximum level of education of the household members. We additionally control for the household type by economic activity, by taking the "maximum" activity of the household members. The households are split to four household types 1) employed, 2) self-employed, 3) pensioner and 4) unemployed [5]. The household characteristics with the exception of total expenditures represent the vector z_{hc} in equations (1) and (2). All expenditure variables, and consequently the unit value of cigarettes, are deflated to 2012 values. The descriptive statistics of the variables used in the estimation of the first stage regressions are presented in table 2.

The data indicates that about 36% of the households have expenses on cigarettes (share of available observations on unit value and budget share). We follow Rijo (2008) and exclude households with zero cigarette consumption from the analysis. We assume that the preferences of consumers and non-consumers are “fundamentally different”, as the consumption of cigarettes does not enter

[4] No cluster has less than two households, which is condition to estimate the Deaton’s model.
[5] We rank the labor market activity of the household members in the following order 1) employed; 2) self-employed, 3) pensioner, 4) unemployed. If there is a member of the household which is employed, the household is labelled as "employed". If there are no employees, in the household, but there are self-employed, the household type is "self-employed". If there are no employees or self-employed, but there is a pensioner in the household, the household is marked as "pensioner, and finally if the adult household members are all inactive or unemployed the household is labelled as "unemployed".

their utility function (Rijo, 2008, p. 203)[6]. We further restrict our analysis to the analysis of the expenditures on cigarettes packs, therefore excluding cut tobacco. This is done for two reasons. Firstly, the implementation of Deaton's model implies the use of the unit values so the aggregation of the expenditures on different tobacco products was not possible. Secondly, according to HBS data the expenditure on cut tobacco represents less than 3% of the total households' expenditures on tobacco products and less than 3% of the households have positive cut tobacco consumption[7]. Additionally, we drop 43 households whose total household expenditure is 5 standard deviations higher or lower than mean expenditure in the overall sample. Total sample for the regression analysis amounts to 9,990 households.

The households that enter first stage regression have average male ratio of about 50%, while the children (i.e. those aged 14 or less) represent about 10% of the household members. Mean and maximum years of education of 10.7 and 12 suggest that on average adult household members have secondary level of education[8]. Furthermore, about 42% of the households are from urban areas, while approximately 58% has at least one person employed with additional 17% of the households having at least one person self-employed. Household type "pensioner" makes about 21%, while household type "unemployed" makes about 4% of the households.

Table 2: Descriptive statistics of variables used in the first-stage regression

	Obs.	Mean	Std dev.	Min	Max
Unit Value, Cigarettes (ln)	9,990	5.15	0.22	3.26	5.80
Budget share, Cigarettes	9,990	0.09	0.06	0.00	0.51
Total expenditure (ln)	9,990	11.01	0.55	7.79	12.43
Household size (ln)	9,990	1.06	0.56	0	3.00
Male ratio	9,990	0.51	0.25	0	1
Adult ratio	9,990	0.90	0.17	0.14	1
Mean education	9,990	10.75	2.36	2	20
Maximum education	9,990	12.03	2.54	2	20
Rural Settlements	9,990	0.42	0.49	0	1
Household type - Employed	9,990	0.58	0.49	0	1

[6] Although the prices of cigarettes can impact the decision to smoke, previous research for India suggests that among the reasons for not smoking, high prices are not too frequent (Rijo, 2006). However, we acknowledge that the evidence for Serbia might be different, although to the date there is none.

[7] Furthermore, the descriptive statistics on cut tobacco do not suggest that these data from the HBS are reliable. The variation of the expenditure is strong (for example, the expenditure from 2012 represents about 10% of the expenditure on cut tobacco from 2016) as well as the calculated unit values (the unit value of cigarettes from 2012 is double the one from 2015). These variations are also probably the result of low sample of households with cut tobacco expenditures.

[8] Approximately equal mean and maximum education suggests education sorting of the household members.

Self-employed	9,990	0.17	0.37	0	1
Pensioners	9,990	0.21	0.41	0	1
Unemployed	9,990	0.04	0.20	0	1

Author's calculation based on the HBS data.

Note: Conditional on being in the first stage regression.

First stage – household level regression

Table 3 presents the results of equations (1) and (2). We first comment on the results of the unit values equation. The coefficient for total expenditure (β^1 from the equation (2)) is significant and it indicates that the quality elasticity of expenditure is about 0.1%. In other words, households with 10% higher expenditure will buy cigarettes that are about 1% more expensive. This result is consistent with the results from other countries (e.g. John, 2008 for India) and indicates that there is quality shading in Serbia. The use of the Deaton's model is therefore necessary for obtaining an unbiased estimate of cigarette price elasticity.

Remaining coefficients from unit value regression have the expected signs: unit value is lower in larger households, if there are more women and elderly in the household, and in rural settlements. Additionally, "pensioner" household type the money spent on the cigarette packs is lower, while the same does not hold for "unemployed" households, although this could be due to their small sample size. There is no effect of education on the unit value. Finally, cluster fixed effects are statistically significant and relatively large, confirming the results in table 1 showing that both spacial and time variation are pronounced.

We now turn to the estimated coefficients from the budget share equation. All other things equal, households with higher levels of expenditure spend lower share of their expenditure on cigarettes. Households with 1% higher expenditure, spend about 0.03 fewer percentage points of their budget on cigarettes.

Table 3: First-stage regression results

VARIABLES	Unit Value (per pack, ln)		Cigarettes budget share (in %)	
Total expenditure (ln)	0.093***	(0.004)	-0.032***	(0.001)
Household size (ln)	-0.055***	(0.004)	-0.010***	(0.002)
Male ratio	-0.013**	(0.006)	0.019***	(0.002)
Adult ratio	-0.048***	(0.010)	0.007*	(0.004)
Mean education	0.002	(0.001)	-0.001**	(0.001)
Maximum education	0.001	(0.001)	-0.001*	(0.000)
Rural Settlements	-0.014***	(0.004)	0.003*	(0.001)

Household type - Employed	omitted			
Unemployed	0.003	(0.007)	0.008***	(0.003)
Pensioners	-0.013***	(0.004)	-0.005***	(0.002)
Self-employed	0.002	(0.004)	-0.001	(0.002)
Cluster dummies	F(736, 9243) 22.748***		F(736, 9243) 2.530***	
Constant	4.211***	(0.039)	-0.463***	(0.015)
Observations	9,990		9,990	
R-squared	0.671		0.311	

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Author's calculation based on the HBS data.

Additionally, budget share spent on cigarettes is larger among smaller households, in households with higher shares of men and adults, but lower in the households where maximum education is higher. Similarly to unit value equation, in "pensioner" households the budget share spent on the cigarettes is lower, while for "unemployed" households the budget share spent on cigarettes is higher than in the "employed" households. Finally, cluster fixed effects are significant and come from both spacial and time variation.

Estimated values of the coefficients for logarithm of total expenditure from equations (1) and (2) are used to arrive to the estimate of the total expenditure elasticity of demand, by using the formula from the equation (12). The estimated value of total expenditure elasticity is, in line with the expectations positive and estimate at 0.532. However, this estimate should be treated with caution, as it indicates the elasticity on intensive margin, i.e. in the sample of households with positive consumption. In other words, among the households which consume cigarettes, 10% higher total expenditure is associated with 5.3% higher the quantity of cigarettes smoked.

Second stage – cluster level estimates of price elasticity

After the formation of the second stage variables (from equations (6) and (7)) we additionally purge regional effects from the variability of the budget share and unit values. Results indicate that regional effects on both unit values and budget shares are significant and that regional preferences play a role in the choice of unit value and the budget share allocation towards cigarettes.

In the final stage of the estimation following the equations (8) to (10) we arrive at the estimated price elasticity of the cigarettes demand. Results indicate a negative price elasticity of -0.450. The same caution in the interpretation mentioned for the total expenditure elasticity should be applied here, as the

estimate indicates the elasticity on intensive margin, i.e. in the sample of households with positive consumption. In other words, if cigarette prices in Serbia increase by 10%, the demand for cigarettes among the smokers of cigarettes will decrease by 4.5%. Standard error of the elasticity, calculated via bootstrapping procedure (1000 replications) indicates that the value of the price elasticity is significantly different from and lower than zero (ξ= -0.450; SE_{ξ} = 0.065, t = -6.923).

5. Conclusions

In this paper we use the Household Budget Survey data (2012-2016) for Serbia and Deaton's demand model to estimate the price elasticity of cigarettes consumption. Employing cigarettes' unit values to approximate their prices, we found a negative price elasticity of demand for cigarettes of -0.450. This result is in line with previous estimates in low- and middle-income countries (Chaloupka et al. 2000). To our best knowledge, this is the first estimate of the price elasticity of cigarettes demand for Serbia, as well as for any Western Balkan country. It demonstrates that the demand for cigarette is responsive to their prices and that tobacco tax policy can be used effectively to reduce cigarette consumption in Serbia.

The results presented depend on two assumptions. Firstly, we assume that the initial consumption of cigarettes does not depend on the cigarette prices (at least not in the short- and mid-term of over maximum five years), due to which households with zero cigarettes consumption were excluded from the analysis, and the estimated price elasticity is on the intensive margin. Additionally, due to methodological reasons and low expenditure (less than 3% of total tobacco consumption), cut tobacco is excluded from the analysis.

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