



## ORIGINAL ARTICLE


**Citation:** Rigelsky, M., Ivankova, V., Gavurova, B., & Mudrik, M. (2020). The effect of the minimum wage on smoking-related indicators in selected OECD countries. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 15(3), 439–461. doi: 10.24136/eq.2020.020

Contact to corresponding author: [beata.gavurova@tuke.sk](mailto:beata.gavurova@tuke.sk); Technical University of Košice; Letná 9, 042 00 Košice, Slovak Republic

Received: 15.04.2020; Revised: 28.07.2020; Accepted: 11.08.2020; Published online: 15.09.2020


### Martin Rigelsky

University of Prešov in Prešov, Slovakia

 [orcid.org/0000-0003-1427-4689](https://orcid.org/0000-0003-1427-4689)


### Viera Ivankova

University of Prešov in Prešov, Slovakia

 [orcid.org/0000-0002-6164-1165](https://orcid.org/0000-0002-6164-1165)


### Beata Gavurova

Technical University of Košice, Slovakia

 [orcid.org/0000-0002-0606-879X](https://orcid.org/0000-0002-0606-879X)

### Martin Mudrik

University of Prešov in Prešov, Slovakia

 [orcid.org/0000-0002-3215-232X](https://orcid.org/0000-0002-3215-232X)

## The effect of the minimum wage on smoking-related indicators in selected OECD countries

**JEL Classification:** J31; I11; I18

**Keywords:** *smoking addiction; smokers; minimum wage; economic development; OECD countries*

### Abstract

**Research background:** The amount of the minimum wage is, in some sense, an indicator of the economic level of a country. There are considerable differences in this indicator between the countries of the Organisation for Economic Co-operation and Development (OECD). At the same time, the minimum wage is also an instrument that largely regulates people's behaviour and affects different areas of life.

**Purpose of the article:** The objective of this study is to determine the relations between the minimum wage and individual smoking-related indicators in a sample of selected OECD countries (16 countries). The study answers the question of whether people in countries with lower minimum wages (lower development) smoke more than in countries with higher minimum wages.

**Methods:** Four variables entered into the analytical processing, the minimum wage, daily smokers (age 15+), daily smokers (age 15–24) and tobacco consumption in grams per capita (age 15+). The data were collected between 2011 and 2017. The analysis was carried out in three steps — descriptive analysis, cluster analysis and regression analysis.

**Findings & Value added:** It has been found that the minimum wage negatively affects smoking and tobacco consumption, i.e. in developed countries, where the minimum wage is higher, people smoke less. Regarding the evaluation of minimum wage and tobacco consumption, countries such as Austria, New Zealand or the United States can be considered positive. On the other hand, opportunities for improvement can be seen in countries such as the Czech Republic, Spain, Estonia and Israel. The study highlights the importance of the effect of the minimum wage on selected smoking-related indicators in selected OECD countries. In all three cases, there was a negative relation; therefore, smoking can be expected to decrease, if the minimum wage is increased.

## Introduction

The minimum wage institute arose from the need for social dialogue after the First World War (Dimsdale, 1984). Under the Treaty of Versailles, it was agreed that employees should be paid a wage that is sufficient to ensure the strengthening of a legitimate standards of living, as understood at a given time and in a given country (Reynauld, 2017). Over time, increasing pressure has been put in place to create universal transnational mechanisms for determining the minimum wage (Boeri, 2012; Waltman, 2000). The minimum wage is currently considered as a certain tool to protect employees against abuse by employers. In OECD countries, the minimum wage is around 40–60% of their average wage (Josifidis & Supic, 2019), which contributes to its importance. In any case, the minimum wage is an important part of countries' economic lives; and therefore, it is discussed in political, professional, but also public society. On the other hand, the minimum wage can affect many aspects of an individual's life, and unhealthy behaviour can be included in these aspects. On this basis, it is possible to ask how the minimum wage affects the number of smokers or the tobacco consumption in countries. This study focuses on the relations between the minimum wage and selected smoking-related indicators in a sample of OECD countries.

The structure of the study is as follows: the section of the literature review is focused on theoretical background, which provides the relevant findings in this area. Subsequently, the objective of the research has been formulated, as well as the data and methodological procedures have been defined. These were applied in the analytical part, in which descriptive analysis, regression analysis and cluster analysis were used. In the conclusion part, we summarize the research findings and we compare them with other studies. Last but not least, we define the political implications and the possibilities for future research in this issue.

## Literature review

The minimum wage is an important element of the economy, both from the point of view of policy makers and individuals. The effects of the minimum wage policy on employee satisfaction, work behaviours and productivity, perceived quality of life, as well as well-being of families, adults and children are indisputable (Ahmat *et al.*, 2019; Hill & Romich, 2015). At the same time, there is the association of changes in the minimum wage with health, including health outcomes, health behaviours and access to health care (Narain & Zimmerman, 2019). Lenhart (2017a) revealed that the minimum wage may improve several health outcomes. Many other authors have investigated the relationship between the minimum wage and the health of the population (Horn *et al.*, 2016; Komro *et al.*, 2016; Andreyeva & Ukert, 2018; Wehby *et al.*, 2018), proving that this issue is well-examined. Overall, it can be stated that the amount of the minimum wage has an undeniable impact on the quality of life of people in individual areas.

In the relationship between the minimum wage and the population health, the risky health behaviour of individuals can also be taken into account. One of these risk factors is smoking, in this article we discuss the impact of the minimum wage on smoking. Regarding the unhealthy behaviour of individuals, Marcus (2014) emphasized that lower socio-economic status of people before job loss shows a high rate of smoking initiation. Therefore, it is possible to see the relationship between the minimum wage and smoking.

Lenhart (2017b) revealed that higher minimum wages have an effect on the population health as well as the health behaviour of the population, including in terms of tobacco consumption. Leigh *et al.* (2019) confirmed that an increase in the minimum wage by 1 USD leads to a reduction in the prevalence of smoking by 1.4 percentage points (on average 4%). These findings are consistent with the results of a study conducted by Du and Leigh (2015), who confirmed that an increase in an individual's wages leads to a reduction in the incidence of smoking in current and past consumers. Therefore, low wages lead to more smoking in the population. Similar conclusions can be seen in many studies, which have revealed that low-income people make more unhealthy choices (Auld, 2005; Brinkley, 2010; Sun, 2019).

This evidence suggests that the minimum wage and its changes may have a significant impact on smoking, and this issue needs to be addressed in order to reduce smoking in the population. Smoking is one of the main lifestyle factors that affect the population health, and there are many nega-

tive effects of smoking (Vineis *et al.*, 2004; Willi *et al.*, 2007; Arnson *et al.*, 2010; Kallas *et al.*, 2019).

Although the number of smokers in OECD countries is gradually decreasing, smoking still remains a relatively serious problem (OECD, 2016; Di Novi & Marenzi, 2019). It should be remembered that tobacco kills more than 8 million people worldwide each year, and the tobacco epidemic is also associated with population morbidity and economic losses (WHO, 2013; 2019). The measures implemented so far to reduce the number of smokers are still below the required level and could be clearly more pronounced (Kaul *et al.*, 2018). Addressing the challenge of smoking requires more radical solutions (Prabhat Jha, 2011).

Based on the above-mentioned findings, policy makers should focus on effective tools that can reduce smoking in the population. As a result, a reduction in smoking can lead to lower population mortality and also economic gains (Chung *et al.*, 2007; Max *et al.*, 2011; Jha *et al.*, 2013; Lightwood & Glantz, 2016; Chen *et al.*, 2019). This study provides insight into this issue in OECD countries and focuses on the minimum wage as a potentially effective tool for reducing the number of smokers.

## **Research methodology**

As the ideas of the previous section suggest, population incomes indicate some effects associated with their inclination to smoking. The analyses presented in this study were focused on assessing the relationships between the minimum wage and selected smoking-related indicators in a sample of selected OECD countries. The primary objective of the presented study was to determine the relations between the minimum wage and individual smoking-related indicators in a sample of selected OECD countries. The following research questions and hypotheses were proposed:

*RQ: Is there a statistically significant relation between the minimum wage and selected smoking-related indicators?*

*H1: It is assumed that the minimum wage has a significant effect on the ratio of daily smokers to the population over 15 years of age.*

*H2: It is assumed that the minimum wage has a significant effect on tobacco consumption per capita.*

H3: *It is assumed that the minimum wage has a significant effect on the ratio of daily smokers to the total population over 15 and under 24 years.*

The analysed data were collected from the OECD databases (OECD, 2019b). The independent variable was represented by the minimum wage (Min\_Wage). The OECD has defined the minimum wage as real hourly and annual minimum wage that is statutory minimum wage converted into a common hourly and annual pay period for the 28 OECD countries and 4 non-member countries for which it is available. The resulting estimates are deflated by national Consumer Price Indices (CPI). The data is then converted into a common currency unit using either USD current exchange rates or USD Purchasing Power Parities (PPPs) for private consumption expenditure. Real hourly and annual minimum wages are calculated first by deflating the series using the consumer price index taking 2018 as the base year. The series are then converted into a common currency unit (USD) using Purchasing Power Parities (PPPs) for private consumption expenditures in 2018 (OECD, 2019a).

The dependent variables included three variables: (i) Smors\_D%15 — Daily smokers (age 15+) — expressed as a percentage of the population aged 15 years and over, this variable is defined by the OECD (2019c) as the percentage of the population aged 15 years old or over who report that they are daily smokers; (ii) Smors\_D%15–24 — Daily smokers (age 15–24) — expressed as a percentage of the population aged 15–24 who are daily smokers, this variable is defined by the OECD (2019c) as the percentage of the population aged 15–24 years old or over who report that they are daily smokers; and (iii) G\_Tob — Tobacco consumption in grams per capita (age 15+) — this variable expresses the annual consumption of tobacco products (e.g. cigarettes, cigars) in grams per person aged 15 years old or more (OECD, 2019d).

The above-mentioned data were collected from 2011 to 2017 for selected OECD countries (Australia (AUS), Canada (CAN), the Czech Republic (CZE), Estonia (EST), France (FRA), Ireland (IRL), Israel (ISR), Japan (JPN), Korea (KOR), Luxembourg (LUX), the Netherlands (NDL), New Zealand (NZL), Spain (ESP), Turkey (TUR), the United Kingdom (GBR), the United States (USA)). These countries were selected on the basis of a parameter that assumed the availability of data for at least 2 years during the analysed period. Countries that reported less than 2 years of available data for the analysed period were excluded from the analyses. Analytical procedures include data from 2011 to 2017 (not all countries reported all data for the analysed period — especially in smoking indicators, there was

a high incidence of missing values). Missing values were not included in the analyses.

The analytical processing was conducted in several successive phases. In the first phase, the data were statistically characterized. Descriptive analysis was performed in order to better understand the variables that entered the analyses. Subsequently, cluster analysis was applied in the second phase. The cluster analysis is an analytical process that results in the creation of homogeneous groups. The creation of these groups identifies countries on the basis of the smallest differences between countries within one group, and at the same time, on the basis of the greatest differences between countries within individual groups. This analysis was performed in several steps, while the optimal number of clusters was estimated in the first step. For this purpose, the silhouette method, the elbow method, the gap method and algorithm combination method were used (Charrad *et al.*, 2014). Subsequently, the most appropriate algorithm was selected using consensus clustering (Monti *et al.*, 2003). Due to the nature of the data, the following algorithms were included in the evaluation process: Nonnegative Matrix Factorization (NMF), Hierarchical Clustering (HC), Divisive Hierarchical Clustering (DIANA), K-Means Clustering (KM), Partition Around Medoids (PAM), Spectral Clustering using Radial-Basis Kernel Function (SC), Gaussian Mixture Model using Bayesian Information Criterion (GMM), Fuzzy C-Means Clustering (CMEANS). The last phase of analytical processing was the application of regression analysis. This analysis assesses the significance of the effects of the minimum wage on smoking and tobacco consumption. Four models were used: (i) a simple regression model, (ii) a simple regression model with quadratic independent variable, (iii) a panel model with a panel variable that determines clusters, and (iv) a panel model with a panel variable that takes into account individual countries. Based on the Gauss-Markov theorem, the primary focus was on the homogeneity of (constant) variability of residues (homoscedasticity), which is one of the most significant characteristics influencing the BLUE (Best Linear Unbiased Estimator) estimate. Heteroscedasticity was tested using the Breusch-Pagan test (Breusch & Pagan, 1979). The suitability of applying the panel models was tested using the F test for time effects. The F test was also used to assess the effects of individual clusters and countries (which entered the panel models). The Hausman test was used to select a fixed effect model or a random effect model. The Ramses RESET test was also applied to assess the relevance of OLS models. All analytical processes were performed using the programming language R v 3.6.1 (Action of the Toes).

## Results

The following section consists of three separate parts. The beginning is devoted to the descriptive analysis of variables and then this section continues with the cluster analysis, in which selected countries were evaluated in terms of the consumption of tobacco products and the minimum wage. The last part includes the applied analysis of relations, which evaluates the effect of the minimum wage on individual smoking-related indicators.

Table 1 presents the information on the basic statistical characteristics of the analysed variables. In the last rows, this table shows the differences in the analysed variables between the categories of selected years and between the categories of countries. In the first step, an analysis of normality was applied, the output of which indicates significant deviations from the normal distribution in all cases except the first. The nonparametric Kruskal-Wallis rank sum test was chosen to evaluate the differences. The high rate of difference was found especially in the case of countries. At this point, it should be emphasized that not all data for all years and countries were available in the database; therefore, some deformations may have occurred due to missing values. However, this bias cannot be considered significant.

Table 2 provides the information for a comprehensive view of the analysed variables and shows the quartile distribution of countries within the analysed variables. The first quartile Q1 represents the first 25% of the ordered set of values, the third quartile Q3 symbolizes the highest 25% of the ordered set of values. In all variables except Min\_Wage, a higher value (higher quartile) represents a more negative output.

The following process is devoted to the application of cluster analysis. The adjustment of the variables included in this analysis was performed in several steps. In the first step, the arithmetic mean of all variables (Smors\_D% 15, G\_Tob, Smors\_D% 15–24, Min\_Wage) was calculated for each country (the year variable for individual countries was included in the average values). Subsequently, the variables were standardized from 0 to 1. From this point, standardized variables are reported in the analysis. The arithmetic mean of the indicators related to smoking and tobacco consumption (Smors\_D% 15, G\_Tob, Smors\_D% 15–24) was calculated again. Two new variables were created: a variable representing the evaluation of the indicators related to smoking and tobacco consumption (EV-SMK) and a variable representing the evaluation of the minimum wage (EV-mWAGE). Subsequently, the variables were standardized from 0 to 1, while 1 represents a more positive evaluation. In the next step, several methods were used to estimate the optimal number of clusters. Based on Figure 1, it can be concluded that the most appropriate number of clusters

is 2. Then several algorithms were verified using the PAM method. Table 3 provides information that DIANA, PAM, KM, SC and GMM can be included among the most suitable algorithms. The SC algorithm is not suitable for the study and it was used only for comparison. Therefore, Table 4 provides information on countries for the DIANA, PAM, KM and GMM algorithms. According to the given table, all algorithms generate the same division of countries into clusters. In the first cluster (1), the average value of EV-SMK was 0.74 and in the second cluster (2), the average value was 0.42. Regarding the variable EV-mWAGE, the first cluster (1) acquired the average value of 0.78 and in the case of the second cluster (2), the average value was 0.24. The second cluster showed worse average values in both variables than the first cluster. The above-mentioned division of countries into clusters also provided the basis for a panel model of regression analysis.

In the first step of the regression analysis, assumptions for the application of simple regression models (OLS) were tested. Based on Gauss-Mark's theorem, heteroscedasticity was assessed using the Breusch-Pagan test. Regarding the effect of Min\_Wage on Smors\_D%15, this test acquired a p-value approximately equal to 0.3741 in a BP statistic of 0.79 (model with quadratic independent variable: BP = 2.07, p-value = 0.1499). In terms of the effect of Min\_Wage on G\_Tob, the test acquired a p-value approximately equal to 0.0004 in a BP statistic of 12.53 (model with quadratic independent variable: BP = 10.83, p-value = 0.0010). And in the case of the effect of Min\_Wage on Smors\_D%15-24, the test acquired a p-value approximately equal to 0.3355 in a BP statistic of 0.93 (model with quadratic independent variable: BP = 1.59, p-value = 0.20). Thus, in the first and third tested models, there was no significant rate of variability of residues (heteroscedasticity). The second model concerning G\_Tob was constructed using the robust estimation method. Although the analysed data are in a very short time series (2011–2017), these years may have some effect and this effect was tested in the following step. In all three models, the F test for time effects gave a p-value higher than 0.05. Based on this, it is not possible to speak of a significant effect of individual years. On the other hand, testing the effects of countries and clusters showed the opposite situation. The analysed countries and the above-mentioned clusters had a significant effect. As can be seen, the panel regression model (cross-sectional) is a very suitable for evaluating the significance of the assumed effects. The selection of the most suitable panel model method was performed using the Hausman test. The cluster variable as a panel variable had two categories; therefore, a fixed effect model was used in these cases. In terms of models with the country variable as a panel variable, based on the Hausman test,



a random effect model was recommended for the model with the dependent variable Smors\_D%15 ( $\chi^2 = 3.80$ , p-value = 0.0513). Also, a random effect model was recommended for the model with the dependent variable G\_Tob ( $\chi^2 = 0.17$ , p-value = 0.68) and finally, a fixed effect model was recommended for the last model with the dependent variable Smors\_D%15-24 ( $\chi^2 = 5.67$ , p-value < 0.0173). A robust HC3 estimator using the Arellano method was selected to estimate the fixed effect in the model concerning G\_Tob, and an HC3 estimator using the White 2 method was selected to estimate the random effect (Swamy-Arora's transformation). Table 5 shows the results of the effects testing.

Table 5 provides the most significant research output, i.e. the results of the regression analysis. The whole assessment of the effects was carried out in four-dimension models, respectively. Specifically, it was a simple OLS model (OLS) as the first model, followed by an OLS model in which the independent variable was squared (OLS quadratic), the third model was a panel model with a panel variable that determines individual clusters (PLM Cluster) and the last was a panel model with a panel variable that takes into account individual countries (PLM Country). Table 6 provides the linearity assessment. Based on the results, it can be seen that OLS quadratic model with the dependent variable Smors\_D% 15 and the models with the dependent variables G\_Tob and Smors\_D%15-24 showed questionable linearity. The PLM country panel model can be considered as the model with the highest degree of entropy, as it takes into account the specificity of the countries. When assessing the significance of the relationships determining the models in Table 3, it is advisable to focus on a p-value that was less than  $\alpha$  (0.05) in most cases. All parameters of the models were evaluated as significant. Based on this, all three hypotheses (H1, H2, H3) mentioned in the methodological section were accepted. The negative value of regression coefficients (Estimates) suggests that as the minimum wage increases, smoking will decrease (in the optics of the given attributes). When interpreting the coefficient of determination (R2), the value of the last relation should be considered low, which indicates a limitation. The most important sense of considering the variability of a dependent variable when changing an independent variable is in predictive activities, in our case it was only an assessment of the significance of the effect. Thus, the third model is acceptable for the purposes of our research. In general, a rate higher than 0.3 (30%) is considered acceptable.

Figure 2, 3 and 4 visualize the relations between the minimum wage and selected smoking-related indicators. The presented figures show the overall effect (black line) on the effects in individual countries (colour line without smooth) as well as on the effects in individual clusters (colour line with

smooth). Overall (black line), the inverse relationship between the minimum wage and smoking-related indicators can be confirmed, suggesting that a reduction in smoking and tobacco consumption may be associated with an increase in the minimum wage. With a focus on the trend in individual clusters in the countries of the second cluster, this trend can be considered as slightly declining, while this cluster consisted of less developed countries. The first cluster showed a rather increasing trend in the case of smoking and a slightly decreasing trend in the case of tobacco consumption. This may explain why the significant effect was confirmed to cluster panel models, but the coefficient of determination was very low. In the case of trends in the countries themselves, there was a high degree of uncertainty due to a lack of observations, but despite this limitation, it is possible to see a different trend between countries. This fact can be explained by the cultural and social specificities of each country.

## **Discussion**

The relationship between the minimum wage and the health behaviour has been shown to be obvious (Narain & Zimmerman, 2019), and smoking is one of the most threatening unhealthy habits. Smoking is undoubtedly a manifestation that has a very negative impact on human health (Vineis *et al.*, 2004; Willi *et al.*, 2007; Arnson *et al.*, 2010; Kallas *et al.*, 2019); and therefore, it requires a great attention from different perspectives (Kulhánek *et al.*, 2018; Kolářová *et al.*, 2019). In addition, the effects of smoking can be seen in the economic dimension (Chung *et al.*, 2007; Max *et al.*, 2011; Lightwood & Glantz, 2016; Chen *et al.*, 2019). These are all reasons why society should be interested in ways to reduce smoking among the population.

This research confirmed the fact that there is some link between the minimum wage and the unhealthy behaviour related to smoking and tobacco consumption. Based on the results of the regression analysis, it can be assumed that a reduction in smoking and tobacco consumption can be associated with an increase in the minimum wage. Therefore, smoking can be expected to decrease if the minimum wage is increased. These findings are consistent with other studies that have revealed the existence of a negative relationship between the minimum wage and smoking (Leigh *et al.*, 2019). Also, Lenhart (2017b) confirmed that minimum wages have an impact on tobacco consumption. The results of this study are in line with Du and Leigh (2015), who argued that low wages lead to a higher prevalence of smoking. In general, these findings confirmed the fact that smoking is more

common in low-income people (Auld, 2005; Brinkley, 2010; Sun, 2019). Accordingly, it can be concluded that smoking is less popular in more developed societies and their culture, level of education, other socio-economic aspects, as well as tobacco policy can play an important role in this regard (Nichter, 2003; Giskes *et al.*, 2005; Piko *et al.*, 2005; Yang *et al.*, 2019; Yildiz, 2020).

Based on this, it can be concluded that the minimum wage has an effect on smoking as well as tobacco consumption, and policy makers should focus on this tool in order to reduce the number of smokers. It can be assumed that an increase in the minimum wage leads to a reduction in smoking. Consequently, a reduction in smoking can lead to lower population mortality and also economic gains. Also, there are many other psychosocial factors that may be associated with the health risk behaviours of the population, especially smoking (Tyas & Pederson, 1998). In this context, well-known factors include depression, stress, social support and social environment, alcohol consumption or drug use (Stephoe *et al.*, 1996; Fergusson *et al.*, 2003; Duko *et al.*, 2019; Jimenez-Trevino *et al.*, 2019; Lee *et al.*, 2020). In any case, reducing unhealthy lifestyles across the population is a major challenge for policy makers who should not forget about education, social support and prevention programs (Pavlas Martanová & Fromberg-erová, 2018). Unhealthy behaviour can be a major burden in the future; and therefore, the effects of the minimum wage must not be overlooked.

## **Conclusions**

The primary objective of present study was to determine the relations between the minimum wage and individual smoking-related indicators in a sample of selected OECD countries. Four variables entered into the analytical processing, the minimum wage in real prices (2018) in USD, the percentage of daily smokers per population aged 15 years or over, the annual tobacco consumption in grams per person older than 15 years (inclusive) and the percentage of daily smokers per population aged 15–24 years. The analysed data were provided by OECD databases from 2011 to 2017 for 16 selected OECD countries that publish the minimum wages.

The analytical processing was carried out by the descriptive analysis, the cluster analysis and the regression analysis. In terms of the average values of variables in selected countries, the population of daily smokers aged 15 and over was 17.91%, tobacco consumption per capita was 1265.82g, the population of daily smokers aged 15–24 was 16.52% and the minimum wage was 7.87 USD per hour. Countries with the highest per-

percentage of daily smokers aged 15 and over include Estonia, Spain and Turkey. In terms of tobacco consumption, countries such as the Czech Republic, Japan and Korea dominate. Countries with a high percentage of smokers aged 15 to 24 include the United Kingdom, France and the Czech Republic. The lowest wage was found in countries such as Turkey, Estonia, the Czech Republic and Israel. The application of the cluster analysis divided the analysed countries into two clusters. In terms of the evaluation of the minimum wage and tobacco consumption, countries such as the Czech Republic, Spain, Estonia, Israel, Japan, Korea and Turkey have great opportunities to catch up with countries such as Australia, Canada, France, the United Kingdom, Ireland, Luxemburg, the Nederland, the New Zealand or the United States of America. All three hypotheses were verified in the analysis of effects and in all three cases there was a negative relation.

The main limitation of this study is the fact that the minimum wage can be considered as a secondary determinant (secondary determinant of countries' maturity); therefore, a potential element that can influence the intensity of smoking may be another indicator affecting the minimum wage. It should also be noted that smoking can be conditioned by culture, social habits, etc. and the wage is only secondary. A potential limitation is also the age and income of individual groups of the population, which can affect the intensity of consumption (groups aged 15–18). The unemployed, who have no income, can also be included in these groups. The analyses included daily smokers, but there are several groups of smokers that were not included, e.g. occasional smokers. Another limitation is the fact that some data were missing in OECD databases. For this reason, the results could be distorted, but these deformations cannot be considered significant. Also, a certain limitation. The fact that the third model acquired lower values of the coefficient of determination can also be considered a certain limitation. These sample specificities can potentially affect the outputs, but due to their nature and the overall idea of the study, we do not anticipate significant deformations and we consider the results to be relevant, as our data define the proportion of the population. However, the findings are a very valuable basis for planned future research. Future research in this field will be oriented to a more detailed examination of the relationships of various attributes of the social, cultural and economic fields in connection with smoking. It is also planned to focus separately on countries with higher and lower minimum wages, as trends in these groups of countries appear to be diametrically opposed.

## References

- Ahmat, N. H. C., Arendt, S. W., & Russell, D. W. (2019). Effects of minimum wage policy implementation: compensation, work behaviors, and quality of life. *International Journal of Hospitality Management*, 81. doi: 10.1016/j.ijhm.2019.04.019.
- Andreyeva, E., & Ukert, B. (2018). The impact of the minimum wage on health. *International Journal of Health Economics and Management*, 18. doi: 10.1007/s10754-018-9237-0.
- Aranson, Y., Shoenfeld, Y., & Amital, H. (2010). Effects of tobacco smoke on immunity, inflammation and autoimmunity. *Journal of Autoimmunity*, 34(3). doi: 10.1016/j.jaut.2009.12.003.
- Auld, M. C. (2005). Smoking, drinking, and income. *Journal of Human Resources*, 40(2).
- Boeri, T. (2012). Setting the minimum wage. *Labour Economics*, 19(3).
- Breusch, T. S., & Pagan, A. R. (1979). A simple test for heteroscedasticity and random coefficient variation. *Econometrica*, 47.
- Brinkley, J. (2010). Low income and poor health choices: the example of smoking. *American Journal of Agricultural Economics*, 92(4). doi: 10.1093/ajae/aaq036.
- Charrad, M., Ghazzali, N., Boiteau, V., & Niknafs, A. (2014). NbClust: an R package for determining the relevant number of clusters in a data set. *Journal of Statistical Software*, 61(6).
- Chen, J., McGhee, S., & Lam, T. H. (2019). Economic costs attributable to smoking in Hong Kong in 2011: a possible increase from 1998. *Nicotine & Tobacco Research*, 21(4). doi: 10.1093/ntr/ntx254.
- Chung, C., Wang, J., Yu, C., & Yang, M. (2007). Lifetime medical expenditure and life expectancy lost attributable to smoking through major smoking related diseases in Taiwan. *Tobacco Control*, 16(6). doi: 10.1136/tc.2006.018986.
- Di Novi, C., & Marenzi, A. (2019). The smoking epidemic across generations, genders, and educational groups: a matter of diffusion of innovations. *Economics & Human Biology*, 33. doi: 10.1016/j.ehb.2019.01.003.
- Dimsdale, N. H. (1984). Employment and real wages in the inter-war period. *National Institute Economic Review*, 110(1).
- Du, J., & Leigh, J. P. (2015). Effects of wages on smoking decisions of current and past smokers. *Annals of Epidemiology*, 25(8). doi: 10.1016/j.annepidem.2015.03.016.
- Duko, B., Melese, Y., & Ebrahim, J. (2019). Determinants of cigarette smoking among adolescents in ethiopia: a cross-sectional study. *Tobacco Induced Diseases*, 17. doi: 10.18332/tid/110800.
- Fergusson, D. M., Goodwin, R. D., & Horwood, L. J. (2003). Major depression and cigarette smoking: results of a 21-year longitudinal study. *Psychological Medicine*, 33(8). doi: 10.1017/S0033291703008596.

- Giskes, K., Kunst, A. E., Benach, J., Borrell, C., Costa, G., Dahl, E., Dalstra, J. A. A., Federico, B., Helmert, U., & Judge, K. (2005). Trends in smoking behaviour between 1985 and 2000 in nine European countries by education. *Journal of Epidemiology and Community Health*, 59(5). doi: 10.1136/jech.2004.025684.
- Hill, H. D., & Romich, J. (2018). How will higher minimum wages affect family life and children's well-being? *Child Development Perspectives*, 12(2). doi: 10.1111/cdep.12270.
- Horn, B. P., Maclean, J. C., & Strain, M. R. (2017). Do minimum wage increases influence worker health? *Economic Inquiry*, 55(4). doi: 10.1111/ecin.12453.
- Jha, P., Landsman, V., Rostron, B., Thun, M., Anderson, R. N., McAfee, T., & Peto, R. (2013). 21st-century hazards of smoking and benefits of cessation in the United States. *New England Journal of Medicine*, 368(4). doi: 10.1056/NEJMsa1211128.
- Jimenez-Trevino, L., Velasco, A., Rodriguez-Revuelta, J., Abad, I., De La Fuente-Tomas, L., Gonzalez-Blanco, L., Garcia-Alvarez, L., Fernandez-Pelaez, A., Menendez-Miranda, I., Florez, G., Garcia-Portilla, P., Bobes, J., & Saiz, P. A. (2019). Factors associated with tobacco consumption in patients with depression. *Adicciones*, 31(4). doi: 10.20882/adicciones.1191.
- Josifidis, K., & Supic, N. (2019). The uncertainty of academic rent and income inequality: the OECD panel evidence. *Journal of Economic Issues*, 53(2).
- Kallas, R., Li, J., & Petri, M. (2019). Association of African-American ethnicity and smoking status with total and individual damage index in systemic lupus erythematosus. *Clinical Rheumatology*, 39. doi: 10.1007/s10067-019-04800-1.
- Kaul, A., Schieler, M., & Agetchen, CH. (2018). *The effect of graphic warning labels on cigarette packages in OECD/EU countries*. Retrieved from [https://www.uni-saarland.de/fileadmin/user\\_upload/Professoren/fr12\\_ProfKaul/Research/20181030\\_KaulSchielerAgethen\\_GWL.pdf](https://www.uni-saarland.de/fileadmin/user_upload/Professoren/fr12_ProfKaul/Research/20181030_KaulSchielerAgethen_GWL.pdf) (12.12.2019).
- Kolářová, E., Homola, D., Kolářová, V., & Kramná, E. (2019). Analysis of substance use and its relation to the tax policy of the Czech Republic. *Adiktologie*, 1(19).
- Komro, K. A., Livingston, M. D., Markowitz, S., & Wagenaar, A. C. (2016). The effect of an increased minimum wage on infant mortality and birth weight. *American Journal of Public Health*, 106(8). doi: 10.2105/AJPH.2016.303268.
- Kulhánek, A., Gabrhelík, R., Novák, D., Burda, V., & Brendryen, H. (2018). eHealth intervention for smoking cessation for Czech tobacco smokers: pilot study of user acceptance. *Adiktologie*, 18(2).
- Lee, H., Lee, H. H., Kang, A., Cha, Y., & Operario, D. (2020). Psychological stress, smoking, and hazardous drinking behaviors in South Korea: findings from the Korea National Health and Nutrition Examination Survey. *Journal of Substance Use*. doi: 10.1080/14659891.2020.1760379.
- Leigh, J. P., Leigh, W. A., & Du, J. (2019). Minimum wages and public health: a literature review. *Preventive Medicine*, 118. doi: 10.1016/j.ypmed.2018.10.005.

- Lenhart, O. (2017a). Do higher minimum wages benefit health? Evidence from the UK. *Journal of Policy Analysis and Management*, 36(4). doi: 10.1002/pam.22006.
- Lenhart, O. (2017b). The impact of minimum wages on population health: evidence from 24 OECD countries. *European Journal of Health Economics*. 18(8). doi: 10.1007/s10198-016-0847-5.
- Lightwood, J., & Glantz, S. A. (2016). Smoking behavior and healthcare expenditure in the United States, 1992-2009: panel data estimates. *Plos Medicine*, 13(5). doi: 10.1371/journal.pmed.1002020.
- Marcus, J. (2014). Does job loss make you smoke and gain weight? *Economica*, 81(324). doi: 10.1111/ecca.12095.
- Max, W., Sung, H., Tucker, L., & Stark, B. (2011). The cost of smoking for California's hispanic community. *Nicotine & Tobacco Research*, 13(4). doi: 10.1093/ntr/ntq245.
- Monti, S., Tamayo, P., Mesirov, J., & Golub, T. (2003) Consensus clustering: a resampling-based method for class discovery and visualization of GeneExpression Microarray data. *Machine Learning*, 52.
- Narain, K. D. C., & Zimmerman, F. J. (2019). Examining the association of changes in minimum wage with health across race/ethnicity and gender in the United States. *BMC Public Health*, 19. doi: 10.1186/s12889-019-7376-y.
- Nichter, M. (2003). Smoking: what does culture have to do with it? *Addiction*, 98. doi: 10.1046/j.1360-0443.98.s1.9.x.
- OECD (2016). *OECD Factbook 2015-2016: economic, environmental and social statistics*. Paris: OECD Publishing. doi: 10.1787/factbook-2015-en.
- OECD (2019a). *Dataset: LFS - real minimum wages*. Retrieved from [https://stats.oecd.org/OECDStat\\_Metadata/ShowMetadata.ashx?Dataset=RMW&Lang=en](https://stats.oecd.org/OECDStat_Metadata/ShowMetadata.ashx?Dataset=RMW&Lang=en) (12.12.2019).
- OECD (2019b). *Non-medical determinants of health*. Retrieved from [https://stats.oecd.org/Index.aspx?DataSetCode=HEALTH\\_LVNG](https://stats.oecd.org/Index.aspx?DataSetCode=HEALTH_LVNG) (12.12.2019).
- OECD (2019c). *OECD Health statistics 2019. Definitions, sources and methods - daily smokers*. Retrieved from <https://stats.oecd.org/wbos/fileview2.aspx?IDFile=4b75ea51-2ba2-4744-a9c4-d6b04b669db5> (12.12.2019).
- OECD (2019d). *OECD health statistics 2019. Definitions, sources and methods - tobacco consumption in grams per capita*. Retrieved from <http://stats.oecd.org/wbos/fileview2.aspx?IDFile=8e59b835-8196-426e-9297-15bc1dab652c> (12.12.2019).
- Pavlas Martanová, V., & Frombergerová, A. (2018). Evaluation of a Czech adaptation of the boys and girls plus prevention programme. *Adiktologie*, 18(3–4).
- Piko, B. F., Luszczynska, A., Gibbons, F. X., & Tekozel, M. (2005). A culture-based study of personal and social influences of adolescent smoking. *European Journal of Public Health*, 15(4). doi: 10.1093/eurpub/cki008.
- Prabhat Jha, M. D. (2011). Avoidable deaths from smoking: a global perspective. *Public Health Reviews*, 33(2).

- Reynauld, E. (2017). The international labour organization and the living wage: a historical perspective. *Conditions of Work and Employment Series*, 90. Retrieved from [http://ilo.org/wcmsp5/groups/public/---ed\\_protect/---protrav/---travail/documents/publication/wcms\\_557250.pdf](http://ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---travail/documents/publication/wcms_557250.pdf) (12.12.2019).
- Sun, Y. W. (2019). Smoking and wage rates - evidence from Japanese panel data. *Japan and the World Economy*, 49. doi: 10.1016/j.japwor.2018.10.002.
- Steptoe, A., Wardle, J., Pollard, T. M., Canaan, L., & Davies, G. J. (1996). Stress, social support and health-related behavior: a study of smoking, alcohol consumption and physical exercise. *Journal of Psychosomatic Research*, 41(2). doi: 10.1016/0022-3999(96)00095-5.
- Tyas, S. L., & Pederson, L. L. (1998). Psychosocial factors related to adolescent smoking: a critical review of the literature. *Tobacco Control*, 7(4). doi: 10.1136/tc.7.4.409.
- Vineis, P., Alavanja, M., Buffler, P., Fontham, E., Franceschi, S., Gao, Y. T., Gupta, P. C., Hackshaw, A., Matos, E., Samet, J., Sitas, F., Smith, J., Stayner, L., Straif, K., Thun, M. J., Wichmann, H. E., Wu, A. H., Zaridze, D., Peto, R., & Doll, R. (2004). Tobacco and cancer: recent epidemiological evidence. *JNCI - Journal of The National Cancer Institute*, 96(2). doi: 10.1093/jnci/djh014.
- Waltman, J. L. (2000). *The politics of the minimum wage*. Chicago: University of Illinois Press.
- Wehby, G., Dave, D., & Khaestner, R. (2018). Effects of the minimum wage on infant health. Retrieved from <https://www.nber.org/papers/w22373.pdf> (12.12.2019).
- WHO (2013). *WHO report on the global tobacco epidemic, 2013: enforcing bans on tobacco advertising, promotion and sponsorship*. Geneva, Switzerland. Retrieved from [http://apps.who.int/iris/bitstream/10665/85380/1/978921505871\\_eng.pdf](http://apps.who.int/iris/bitstream/10665/85380/1/978921505871_eng.pdf) (12.12.2019).
- WHO (2019). *Tobacco*. Retrieved from <https://www.who.int/en/news-room/fact-sheets/detail/tobacco> (12.12.2019).
- Willi, C., Bodenmann, P., Ghali, W. A., Faris, P. D., & Cornuz, J. (2007). Active smoking and the risk of type 2 diabetes - a systematic review and meta-analysis. *JAMA - Journal of the American Medical Association*, 298(22). doi: 10.1001/jama.298.22.2654.
- Yang, Z. Y., Floyd, K., & Tanner, J. F. (2019). Effects of antismoking messages from media on adolescent smoking: the roles of family, school, and culture. *Journal of Business Research*, 103. doi: 10.1016/j.jbusres.2019.06.006.
- Yildiz, F. (2020). Determinants of cigarette consumption in Turkey: an ARDL bounds testing approach. *Addicta - The Turkish Journal on Addictions*, 7(2). doi: 10.5152/ADDICTA.2020.19045.

## Acknowledgments

This work is supported by the Scientific Grant Agency of the Ministry of Education, Science, Research, and Sport of the Slovak Republic and the Slovak Academy



Sciences as a part of the research project VEGA 1/0797/20: “*Quantification of Environmental Burden Impacts of the Slovak Regions on Health, Social and Economic System of the Slovak Republic*”.

## Annex

**Table 1.** Descriptive statistics of analysed variables

| Descriptive statistic | Smors_D%15 | G_Tob   | Smors_D%15-24 | Min_Wage |
|-----------------------|------------|---------|---------------|----------|
| N                     | 80         | 83      | 71            | 112      |
| Mean                  | 17.91      | 1265.82 | 16.52         | 7.87     |
| Median                | 18.00      | 1077.80 | 15.90         | 8.09     |
| Std. Deviation        | 3.59       | 497.61  | 5.56          | 2.53     |
| Skewness              | 0.29       | 0.83    | 0.70          | -0.12    |
| Kurtosis              | -0.08      | -0.37   | 0.46          | -1.02    |
| Minimum               | 10.50      | 591.20  | 6.80          | 2.91     |
| Maximum               | 27.30      | 2373.00 | 33.20         | 11.88    |
| Percentiles 25        | 15.38      | 866.10  | 12.70         | 5.92     |
| Percentiles 75        | 20.00      | 1581.00 | 18.80         | 10.09    |
| SW test               | 0.99       | 0.90†   | 0.96**        | 0.96***  |
| KW - year             | 10.89*     | 1.32    | 6.7           | 1.78     |
| KW - country          | 66.93†     | 75.81†  | 58.08†        | 107.98†  |

Note: \* p value < 0.1, \*\* p value < 0.05, \*\*\* p value < 0.01, † p value < 0.001

**Table 2.** Quartile classification of individual countries within smoking and minimum wage

| Country        | Smors_D%15 | G_Tob | Smors_D%15-24 | Min_Wage |
|----------------|------------|-------|---------------|----------|
| Australia      | Q1         | Q1    | Q1            | Q4       |
| Canada         | Q1         | NA    | Q1            | Q2-Q3    |
| Czech Rep      | Q2-Q3      | Q4    | Q4            | Q1       |
| Estonia        | Q4         | NA    | Q2-Q3         | Q1       |
| France         | NA         | Q2-Q3 | Q4            | Q4       |
| Ireland        | Q2-Q3      | Q1-Q2 | Q1            | Q2-Q3    |
| Israel         | Q1-Q2      | Q1-Q2 | NA            | Q1       |
| Japan          | Q2-Q3      | Q4    | NA            | Q1-Q2    |
| Korea          | Q2-Q3      | Q4    | Q1-Q2         | Q1-Q2    |
| Luxembourg     | Q1-Q2      | NA    | Q1-Q2         | Q4       |
| Netherlands    | Q1-Q2      | NA    | Q2-Q3         | Q4       |
| New Zealand    | Q1         | Q1    | Q1-Q2         | Q2-Q3    |
| Spain          | Q4         | Q2-Q3 | Q2-Q3         | Q1-Q2    |
| Turkey         | Q4         | Q1-Q2 | Q2-Q3         | Q1       |
| United Kingdom | Q1-Q2      | Q1    | Q4            | Q2-Q3    |
| United States  | Q1         | Q2-Q3 | Q1            | Q1-Q2    |

Note: NA – missing value.

**Table 3.** Proportion of ambiguous clustering (PAC)

| k | NMF<br>Brunet | NMF<br>Lee | HC<br>Euclidean | DIANA<br>Euclidean | PAM<br>Euclidean | KM   | SC   | GMM  | CMEANS |
|---|---------------|------------|-----------------|--------------------|------------------|------|------|------|--------|
| 2 | 0.52          | 0.44       | 0.11            | 0.00               | 0.00             | 0.00 | 0.00 | 0.00 | 0.65   |
| 3 | 0.53          | 0.52       | 0.28            | 0.07               | 0.30             | 0.41 | 0.31 | 0.36 | 0.45   |
| 4 | 0.53          | 0.45       | 0.25            | 0.25               | 0.29             | 0.28 | 0.23 | 0.40 | 0.38   |

**Table 4.** Cluster distribution

|       | AUS | CAN | CZE | ESP | EST | FRA | GBR | IRL | ISR | JPN | KOR | LUX | NDL | NZL | TUR | USA |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| DIANA | 1   | 1   | 2   | 2   | 2   | 1   | 1   | 1   | 2   | 2   | 2   | 1   | 1   | 1   | 2   | 1   |
| PAM   | 1   | 1   | 2   | 2   | 2   | 1   | 1   | 1   | 2   | 2   | 2   | 1   | 1   | 1   | 2   | 1   |
| KM    | 1   | 1   | 2   | 2   | 2   | 1   | 1   | 1   | 2   | 2   | 2   | 1   | 1   | 1   | 2   | 1   |
| GMM   | 1   | 1   | 2   | 2   | 2   | 1   | 1   | 1   | 2   | 2   | 2   | 1   | 1   | 1   | 2   | 1   |

**Table 5.** Regression analysis

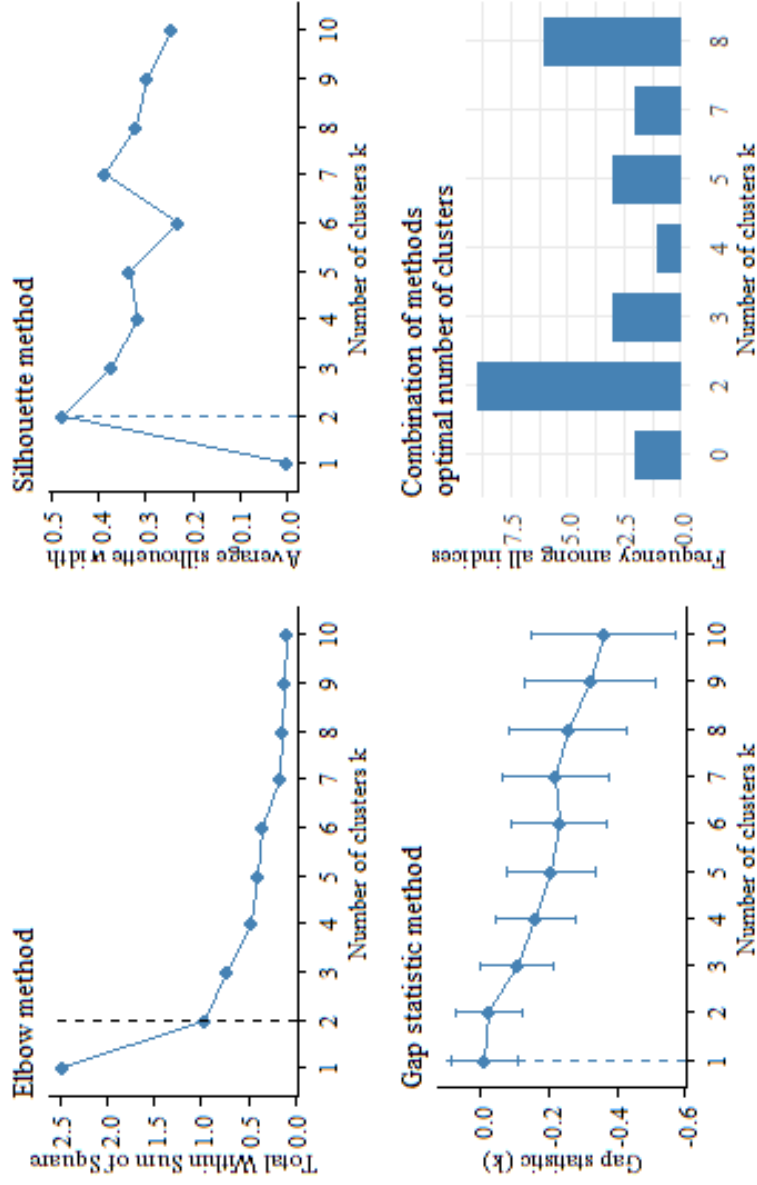
| Independent<br>Minimum<br>Wage | Smors_D%15       |                   | G_Tob                |                     | Smors_D%15-24    |                    |
|--------------------------------|------------------|-------------------|----------------------|---------------------|------------------|--------------------|
|                                | Constant<br>(SE) | Predictor<br>(SE) | Constant<br>(SE)     | Predictor<br>(SE)   | Constant<br>(SE) | Predictor<br>(SE)  |
|                                | $R^2$            |                   | $R^2$                |                     | $R^2$            |                    |
| OLS                            | 24.83†<br>(1.17) | -0.89†<br>(0.14)  | 2301.68†<br>(181.32) | -134.65†<br>(20.15) | 23.09†<br>(2.11) | -0.82***<br>(0.25) |
|                                | 0.33             |                   | 0.39                 |                     | 0.13             |                    |
| OLS quadratic                  | 21.45†<br>(0.73) | -0.05†<br>(0.01)  | 1773.38†<br>(110.65) | -7.87†<br>(1.26)    | 19.61†<br>(1.34) | -0.04**<br>(0.02)  |
|                                | 0.28             |                   | 0.34                 |                     | 0.09             |                    |
| PLM Cluser                     | -                | -0.16<br>(0.06)   | -                    | -68.54**<br>(31.45) | -                | -0.18<br>(0.47)    |
|                                | 0.01             |                   | 0.05                 |                     | 0.01             |                    |
| PLM Country                    | 29.30<br>(0.25)  | -1.42†<br>(0.03)  | 2450.55†<br>(255.41) | -153.32†<br>(27.55) | -                | -2.70†<br>(0.75)   |
|                                | 0.47             |                   | 0.31                 |                     | 0.19             |                    |

Note: \* p value < 0.1, \*\* p value < 0.05, \*\*\* p value < 0.01, † p value < 0.001

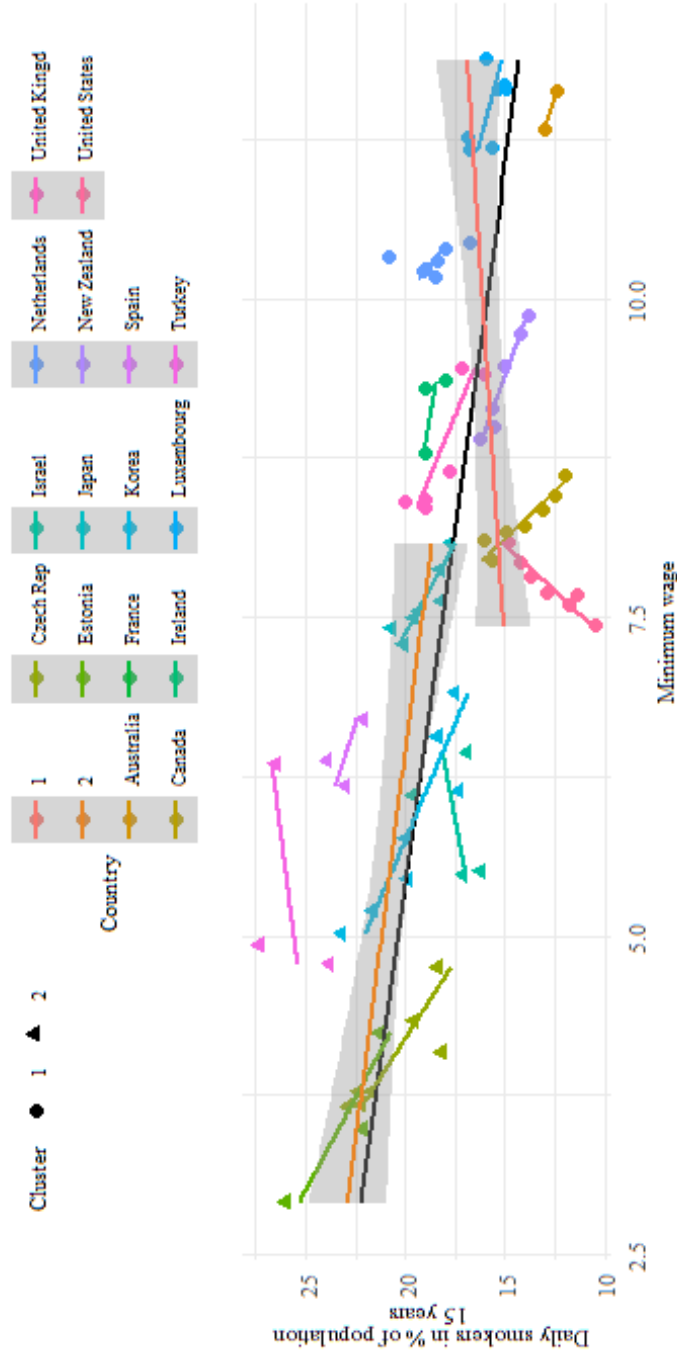
**Table 6.** Linearity test

| Ramsey<br>RESET test | Smors_D%15<br>RESET (p value) | G_Tob<br>RESET (p value) | Smors_D%15-24<br>RESET (p value) |
|----------------------|-------------------------------|--------------------------|----------------------------------|
| OLS                  | 2.59 (0.0814)                 | 4.39 (0.0156)            | 7.92 (0.0008)                    |
| OLS quadratic        | 5.98 (0.0021)                 | 7.17 (0.0014)            | 11.55 (<0.0001)                  |

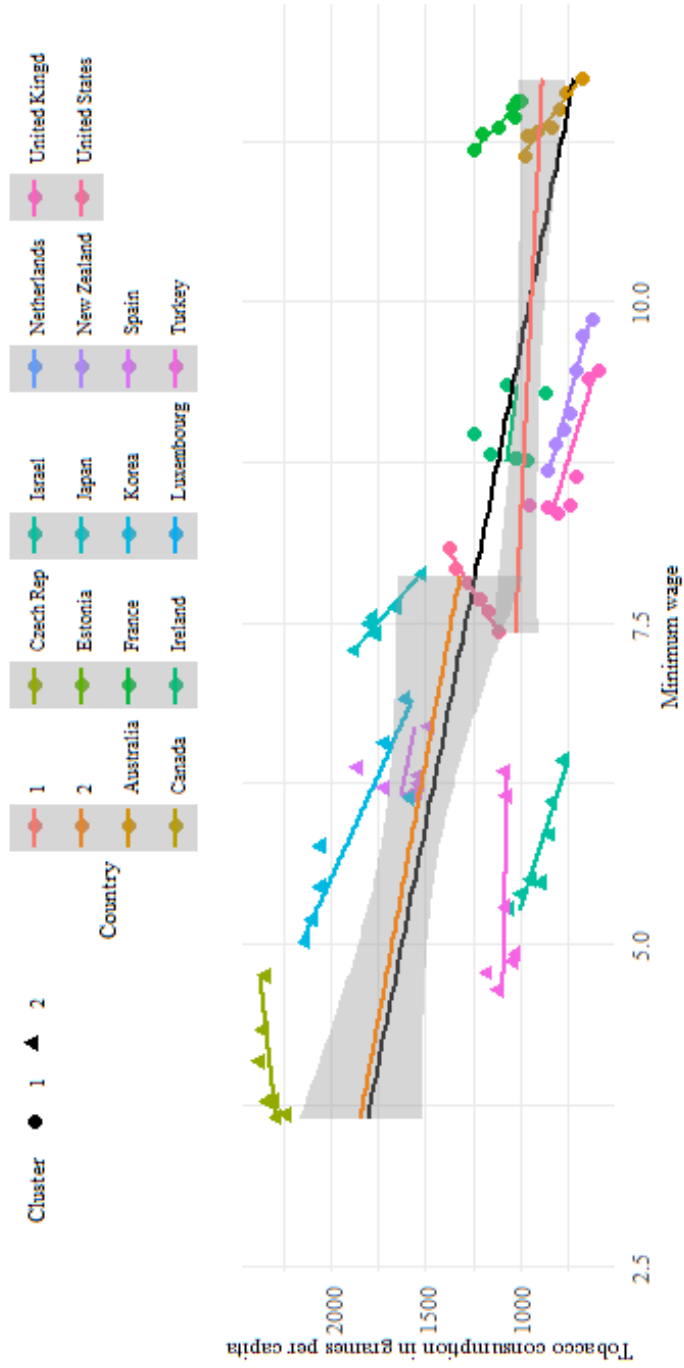
**Figure 1.** Optimal number of clusters



**Figure 2.** Relationship between minimum wage and daily smokers (aged 15+)



**Figure 3.** Relationship between minimum wage and tobacco consumption



**Figure 4.** Relationship between minimum wage and daily smokers (aged 15-24)

