# “An economic view of the innovation potential, the tendencies of smoking in the developed countries and the importance of marketing in this field”


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| **ARTICLE INFO** | Martin Rigelsky, Viera Ivankova, Beata Gavurova and Jaroslav Gonos (2020). An economic view of the innovation potential, the tendencies of smoking in the developed countries and the importance of marketing in this field. *Innovative Marketing* , *16*(2), 43-53. doi:10.21511/im.16(2).2020.04 |
| **DOI** | http://dx.doi.org/10.21511/im.16(2).2020.04 |
| **RELEASED ON** | Wednesday, 27 May 2020 |
| **RECEIVED ON** | Saturday, 18 April 2020 |
| **ACCEPTED ON** | Wednesday, 20 May 2020 |





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|---|---|
| **JOURNAL** | "Innovative Marketing " |
| **ISSN PRINT** | 1814-2427 |
| **ISSN ONLINE** | 1816-6326 |
| **PUBLISHER** | LLC “Consulting Publishing Company “Business Perspectives” |
| **FOUNDER** | LLC “Consulting Publishing Company “Business Perspectives” |

| NUMBER OF REFERENCES | NUMBER OF FIGURES | NUMBER OF TABLES |
|---|---|---|
| 48 | 3 | 6 |

BUSINESS PERSPECTIVES

LLC "CPC "Business Perspectives"
Hryhorii Skovoroda lane, 10,
Sumy, 40022, Ukraine

www.businessperspectives.org

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# AN ECONOMIC VIEW OF THE INNOVATION POTENTIAL, THE TENDENCIES OF SMOKING IN THE DEVELOPED COUNTRIES AND THE IMPORTANCE OF MARKETING IN THIS FIELD

**Received on:** 18th of April, 2020
**Accepted on:** 20th of May, 2020
**Published on:** 27th of May, 2020



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## Abstract

Smoking, as one of the main causes, is a negative factor associated with many diseases. The primary objective of the research is to determine the effect of innovation on selected smoking indicators in a sample of countries of the Organization for Economic Co-operation and Development (OECD). Four variables enter the analytical processing, such as Global Innovation Index, Population ratio of daily smokers (age 15+), Daily smokers (age 15-24), and Tobacco consumption in grams per capita (age 15+). These variables were included in the research from 2011 to 2018. The simple linear regression – the Ordinary Least Squares (OLS) model – and correlation analysis – Spearman's rank correlation – was used for statistical processing. The results show that the effect of innovation on the ratio of daily smokers over the age of 15 to the total population may be considered a highly significant relationship. The effect on the annual tobacco consumption per capita is the second most significant relationship, and the effect on the ratio of daily smokers over 15 and under 24 years to the total population is the least significant compared to the previous two cases. Correlation analysis shows similar outputs. All these relationships may be considered negative. It is possible to talk about the lost innovation potential associated with smoking, primarily in the productive part of the population. A higher level of smoking can be associated with a lower level of innovation. Also, innovation negatively affects the tendency to smoke. Therefore, public policies should promote a healthy lifestyle.

**Keywords** smoking, smokers, consumption, health, innovation, tobacco, Global Innovation Index, OECD

**JEL Classification** O32, I12, I15

## INTRODUCTION

Smoking and tobacco consumption are among the main determinants of public health. Tobacco consumption represents a major global threat to avoidable death and morbidity around the world. At the same time, this health problem causes economic damage (WHO, 2013, 2019). These are the reasons why society as a whole should address the consequences of smoking. This problem can also be perceived in terms of innovation potential. Marketing tools should be used to support the reduction of smoking and innovation in the country. Social marketing in the field of public health and marketing of technological innovation is well known (Grier & Bryant, 2005; Danaher, Hardie, & Putsis, 2001). In this respect, marketing plays an important role in terms of health and innovation. This study deals with the effect of innovation on selected smoking-related indicators in a sample of OECD countries.



**Conflict of interest statement:**
Author(s) reported no conflict of interest

# 1. LITERATURE REVIEW

Aksoy, Bilgic, Yen, and Urak (2019) identified two main effects of addictive (tobacco and alcohol) costs in families: the effect related to the reduction of costs for other common needs (food, education, or health) and the indirect effect related to increased health care expenditure. This is in line with evidence that daily tobacco use is negatively related to the expenditure of families on education and health care (Do & Bautista, 2015). Another evidence also illustrates a negative economic effect of smoking and confirms that smoking is related to poor health of population, reduced productivity, which may threaten the economic development (Rice, Hodgson, Sinsheimer, Browner, & Kopstein, 1984; Max, Sung, Tucker, & Stark, 2011). There are many negative effects of smoking on health, which may lead to cardiovascular and cutaneous damage (Kallas, Li, & Petri, 2019; Gavurova, Vagasova, & Grof, 2017; Gavurová, Huculová, & Kováč, 2019), respiratory and autoimmune disorders (Arnson, Shoenfeld, & Amital, 2010), risk of cancer (Peto, Darby, Deo, Silcocks, Whitley, & Doll, 2000; Vineis, Alavanja, Buffler, Fontham et al., 2004), risk of diabetes (Hu, Manson, Stampfer et al., 2001; Willi, Bodenmann, Ghali, Faris, & Cornuz, 2007), risk of coronary heart disease (Stampfer, Hu, Manson, Rimm, & Willett, 2000; Critchley & Capewell, 2003). Life-long cigarette consumers show a higher incidence of common illness, such as atherosclerosis and COPD (Yanbaeva, Dentener, Creutzberg, Wesseling, & Wouters, 2007). Thun, Carter, Feskanich et al. (2013) found that the risk of death due to smoking among women continues to rise, and the increased risks are currently almost the same for men and women, as compared with people who are non-smokers. It can also be emphasized that the life expectancy of smokers is shorter than that of non-smokers (Jha, Landsman, Rostron et al., 2013). Based on the above, tobacco consumption negatively affects investment in the development of human capital. Addressing the tobacco use issue could benefit not only the health and economic well-being of smokers and their immediate families, but also long-run economic development at a societal level (Do & Bautista, 2015). In line with this statement, tobacco control is very important (Reddy, Yadav, Arora, & Nazar, 2012; Palali & van Ours, 2019), and taxation may be one of the most cost-effective means of discouraging tobacco use (Aksoy, Bilgic, Yen, & Urak, 2019; Chaloupka, 2013). Tabuchi, Fukui, and Gallus (2019) highlighted a relatively short-term effect of higher cigarette prices. On the other hand, Odermatt and Stutzer (2015) confirmed that higher prices of cigarettes reduce the life satisfaction of likely smokers. Last but not least, evidence suggests that smoking cessation at any age has significantly reduced mortality (Thun et al., 2013), and this is the main reason why economies should be focused on smoking cessation. According to Jha et al. (2013), quitting smoking before the age of 40 reduces the risk of death from continued smoking by approximately 90%. On the other hand, the findings showed that the European consumers who started smoking before the age of 16 years were less willing to stop smoking compared to consumers who started smoking after the age of 16 years (Pesce, 2019). Although smoking has a decreasing trend in OECD countries (OECD, 2016), smoking is one of the main public health threats, and this issue should be addressed from various perspectives, including in terms of innovation and technology. Innovative technology, such as smartphones, can be a significant element in health care, individual health education, disease self-management, and remote patient monitoring (Mosa, Yoo, & Sheets, 2012). The smoking issue has a large potential in using smartphones (B. Hoeppner, S. Hoeppner, Seaboyer, Schick et al., 2016; Iacoviello, Luo, Klein, Steinerman, Berger et al., 2017; Peiris, Wright, News et al., 2019). Ali, Zhang, and Soomro (2019) believe that mHealth and QRC technologies are modern innovative tools that can help improve the health of tobacco consumers in terms of smoking cessation. The authors supported anti-tobacco QR codes printed on cigarette packs. According to Baskerville, Struik, Hammond et al. (2015), in terms of cost-effectiveness, mHealth technology can reach a larger part of the population and help young adult tobacco consumers to quit smoking. The results of other study confirmed that potentially effective behavior change techniques could be identified in smoking cessation applications (Ubhi, Michie, Kotz et al., 2015), and eHealth and mHealth should be developed to support smoking cessation (Borrelli, Bartlett, Tooley, Armitage, & Wearden, 2015). BinDhim, McGeechan, and Trevena (2014) also investigated the effectiveness of smartphone applications focused on smoking quitting, and the results showed that the use of these applications for one month leads to abstinence, and in the case


http://dx.doi.org/10.21511/im.16(2).2020.04

of their use for six months, it is possible to speak of continuous abstinence from smoking. Reychav, McHaney, Hirak, and Merker (2019) confirmed that changing unhealthy smoking habits, which play an important role in improving health and healthy lifestyle habits, can be stimulated by the active involvement and development of modern and innovative technologies. All the technologies mentioned above may be characterized as innovative elements of modern life, and several studies dealt with their effectiveness in health care (Ahlan & Ahmad, 2014; Berkowitz, Zullig, Koontz, & Smith, 2017). Thus, the innovative aspect of health, especially in smoking, is very important, and innovative technologies may affect the number of smokers in the country. Therefore, the innovative level of the country should be highlighted. It is difficult to find studies that deal with the macroeconomic view of the relationship between the country's innovation index and the country's overall smoking status. On the other hand, some studies examined responsible innovation in health care (Buttigieg, 2019). Totskaya and Sadovoy (2014) stated that active development of innovation in the area of health care enables the transfer of innovative technologies to the real economy, and promotes integration into the global environment of innovation. This article emphasizes the importance of an innovative view of a specific field of health care and deals with a relationship of tobacco consumption of the population and innovation index in OECD countries.

## 2. METHODOLOGY

Based on the mentioned above, it can be concluded that smoking has consequences for the overall economy of the countries. For this reason, it is important to focus on the issue of smoking and its reduction. The innovation index determines a country's innovation potential from several perspectives. In countries with higher innovation performance, a lower tendency for smoking and tobacco consumption can be expected. The study's primary objective is to determine the effect of innovation on selected smoking indicators in a sample of OECD countries.

The analyzed data (variables) were collected from OECD databases (OECD, 2019a) and reports from the Global Innovation Index (GII) (GII, 2019). The GII index presents the aggregate innovation potential expressed in 7 areas (institutions, human capital and research, infrastructure, marker sophistication, business sophistication, knowledge and technology outputs, creative outputs). This variable was expressed by a value in the theoretical interval of 1 to 100, and a higher value represents a more positive result for a country. Dependent variables included Smors_D%15 – Daily smokers (age 15+) – (percent of a population aged 15+ who are daily smokers), definition: Daily smokers is defined as the percentage of the population aged 15 years old or over who report that they are daily smokers; Smors_D%15-24 – Daily smokers (age 15-24) – (percent of a population aged 15-24 who are daily smokers), definition: Daily smokers is defined as the percentage of the population aged 15-24 years old or over who report that they are daily smokers (OECD, 2019b); G_Tob – Tobacco consumption in grams per capita (age 15+) – (grams per capita (15+)), definition: Annual consumption of tobacco items (e.g., cigarettes, cigars) in grams per person aged 15 years old or more (OECD, 2019c). The above data were collected from 2011 to 2018 for all OECD countries (36).

Methods of regression analysis – simple linear regression OLS – was used for statistical processing. Based on the Gauss-Markov theorem, the primary focus was on homogeneity (constant) variability of residues (homoscedasticity), which is one of the most significant characteristics influencing the BLUE (best linear unbiased estimator) estimate. Heteroscedasticity was tested by using Breusch-Pagan test (Breusch & Pagan, 1979). The outliers were tested secondary by using the Bonferroni test (Cook & Weisberg, 1982). The non-parametric Spearman's rank correlation coefficient ρ was used to analyze the relationship. This method was selected based on the output of multivariate normality, using the Royston test of multivariate normality. Analytical processes were realized by using the programming language R v 3.6.1 (Action of the Toes).

## 3. RESULTS

The following section of the study is focused on the analytical processing leading to the fulfillment of the primary objective interpreted in

**Table 1.** Descriptive statistics of variables

| Descriptive | GII | Smors_D%15 | Smors_D%15-24 | G_Tob |
|---|---|---|---|---|
| N | 288 | 144 | 129 | 143 |
| Missing N | 0 | 144 | 159 | 145 |
| Mean | 51.15 | 17.1431 | 15.0535 | 1,324.4091 |
| Median | 52.62 | 17.0500 | 14.8000 | 1,120.1000 |
| Std. deviation | 7.98 | 4.2979 | 5.8911 | 583.7598 |
| Skewness | –0.29 | 0.1173 | 0.3292 | 13,983 |
| Kurtosis | –0.64 | –0.4315 | 0.2756 | 2.0613 |
| Q1 | 45.21 | 13.8500 | 11.5000 | 905.0000 |
| Q3 | 56.81 | 19.9750 | 18.5000 | 1,625.0000 |

the previous section. The basic characteristics of descriptive statistics are shown at the beginning of this section and primarily dealt with testing the homogeneity of the variability of residuals. Individual regression models were also tested for the presence of significant outliers. Subsequently, regression models are shown to identify the effect of a country's innovation on tobacco consumption (smoking) and its statistical significance. Table 1 shows the basic descriptive statistics.

Table 1 shows the basic statistical characteristics of the analyzed variables. As it may be deduced, the first rows show the number of variables and the number of missing values. Data were analyzed over a period of 8 years (2011–2018), when the occurrence of missing values was very frequent (not every country reported/provided selected data for each year). In this case, specific characteristics, such as stationarity or autocorrelation are not a threat that could affect the overall output of the model. Outputs of central tendency, variability, skewness, kurtosis, and quartiles are also shown. These characteristics help to complete the overall picture of the analyzed data.

Three models are involved in the analysis:

- model 1 determines the effect of GII on G_Tob;
- model 2 determines the effect of GII on Smors_D% 15-24; and
- model 3 determines the effect of GII on Smors_D% 15.

Table 2 shows the output of homoscedasticity testing.

**Table 2.** Homoscedasticity test – Breusch-Pagan statistic

| OLS model | Breusch-Pagan statistic | *p*-value | Significant heteroscedasticity |
|---|---|---|---|
| Model 1 | 35.1740 | $3.02\times10^{-9}$ | Present |
| Model 2 | 0.6868 | 0.4073 | Not present |
| Model 3 | 1.4433 | 0.2296 | Not present |

Table 2 shows the output of the homoscedasticity test that reveals the variability of residuals. Based on a *p*-value, it may be concluded that the assumption of homoscedasticity was not met in model 1 (BP = 35.1740; *p*-value < 0.001). The presence of significant outliers was tested using the Bonferroni Outlier Test, which reveals that no significant outliers can be confirmed in model 1, model 2, and model 3.

## 3.1. The effect of global innovation activities on tobacco consumption (model 1)

This part of the analysis assesses the assumption that innovation represented by the Global Innovation Index affects the tobacco consumption (in grams per person older than 15 years) in OECD countries. The simple linear regression model was applied for statistical processing based on the results of the assumption testing. The coefficients were estimated by using the HC3 estimator. Table 3 shows the test outputs.

Table 3 shows the output of regression model 1, using the HC3 estimator. This model indicates the *p*-values of constancy and independent variable less than 0.05. Thus, there is a significant effect. The *p*-values are shown in the last column. The determination coefficient $R^2$ was approximately equal to 0.0536, and adjusted $R^2$


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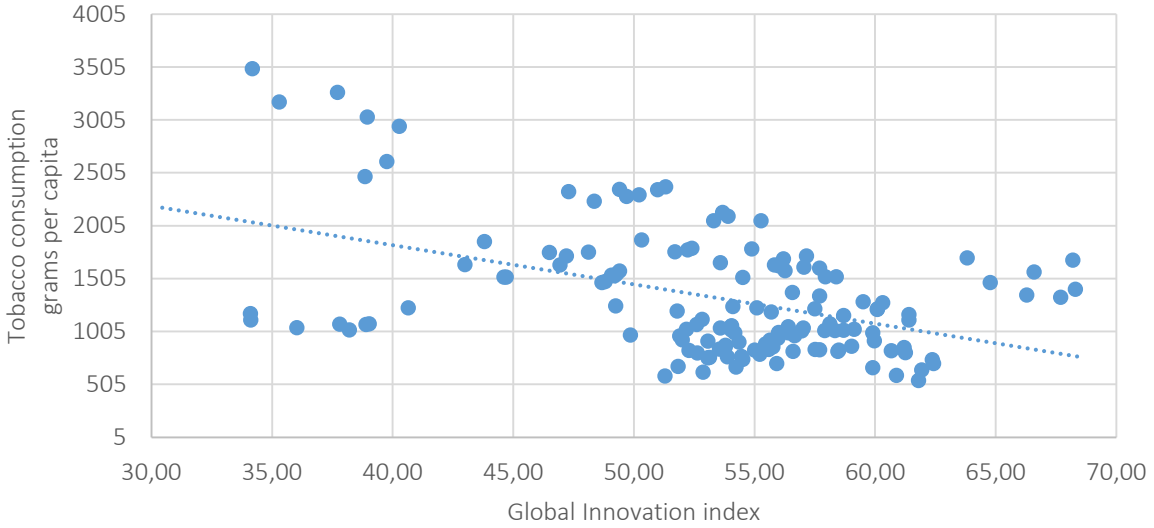


**Figure 1.** Relationship between GII and G_Tob

**Table 3.** Regression analysis – model 1

| Model 1 – F = 37.43(<0.001) $R^2$ = 0.21; $R^2$ adj. = 0.20 | Estimate | Std. error | *t*-value | Pr (> \|*t*\|) |
|---|---|---|---|---|
| (Intercept) | 3302.80 | 4.08 | 810.2 | < 2.20×$10^{-16}$ |
| GII | –37.05 | 0.07 | –505.2 | < 2.20×$10^{-16}$ |

*Note:* $F$ = 37.43 (< 0.001); $R^2$ = 0.21; $R^2$ adj. = 0.20.

was 0.046, i.e., approximately 5% of the dependent variable's variability, and the independent variable determined it. Figure 1 visualizes this output.

Figure 1 shows a negative relationship between innovation and tobacco consumption. It may be assumed that the higher the country's innovation potential, the fewer people consume tobacco.

## 3.2. The effect of innovation activities on the ratio of smokers older than 15 years and younger than 24 years (model 2)

This part of the analysis assesses the assumption that innovation represented by the Global Innovation Index affects the ratio of smokers over the age of 15 and under the age of 24 years to the total population in OECD countries. The simple linear regression – Ordinary Least Square (OLS) model – was used for statistical processing based on the results of the assumption testing. Table 4 shows the test outputs.

Table 4 shows the output of regression model 2. For a residual standard error, it approximately equals to 5.75 on 127 degrees of freedom, and an F-statistic approximately equals to 7.197. This model indicates the *p*-values of constancy and independent variable of less than 0.05; therefore, there is a significant effect. The *p*-values are shown in the last column. The determination coefficient $R^2$ was approximately equal to 0.0536, and adjusted $R^2$ was 0.046, i.e., approximately 5% of the variability of the dependent variable, and the independent variable determines it. Figure 2 visualizes this output.

**Table 4.** Regression analysis – model 2

| Model 2 – F = 7.20 (0.008) $R^2$ = 0.05; $R^2$ adj. = 0.05 | Estimate | Std. error | *t*-value | Pr (> \|*t*\|) |
|---|---|---|---|---|
| (Intercept) | 26.21 | 4.19 | 6.26 | 5.55×$10^{-9}$ |
| GII | –0.21 | 0.08 | –2.68 | 8.28×$10^{-3}$ |

*Note:* $F$ = 7.20 (0.008); $R^2$ = 0.05; $R^2$ adj. = 0.05.

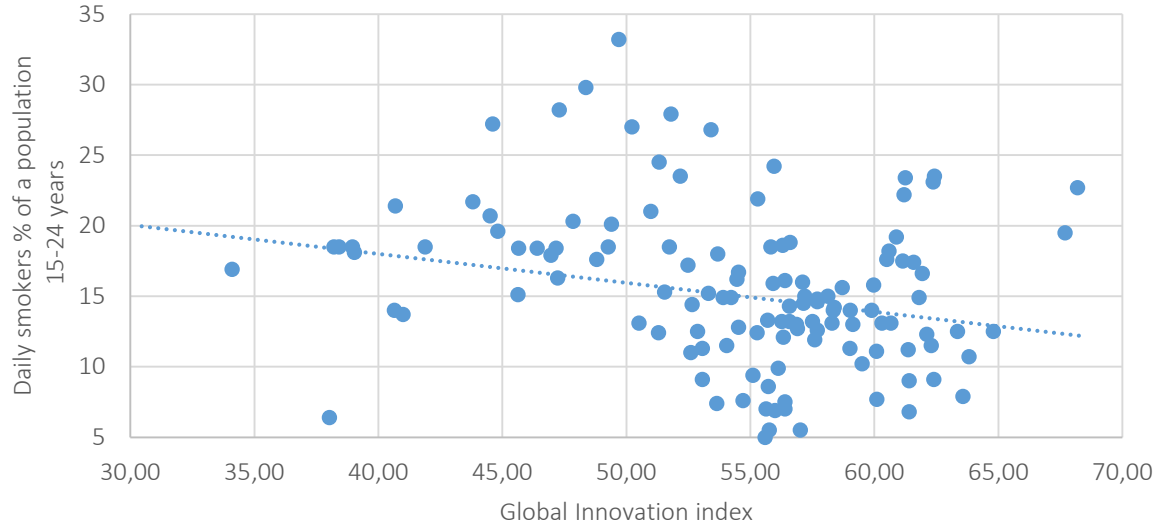


**Figure 2.** Relationship between GII and Smors_D%15-24

Figure 2 shows a slightly declining relationship between innovation and the ratio of smokers over 15 and under 24 years to the total population. It may be assumed that the higher the country's innovation potential, the lower the ratio of smokers over 15 and under 24 years to the total population.

## 3.3. The effect of the innovation activities on the ratio of smokers older than 15 years (model 3)

This part of the analysis assesses the assumption that innovation represented by the Global Innovation Index affects the ratio of smokers over the age of 15 to the total population in OECD countries. The simple linear regression – Ordinary Least Square (OLS) model – was used for statistical processing based on the results of the assumption testing. The coefficients were estimated by using the HC3 estimator. The following Table 5 shows the test outputs.

Table 5 shows the output of regression model 3. For a residual standard error, it equals to 3.43 on 138 degrees of freedom and an F-statistic approximately equal to 64.31. This model indicates the *p*-values of constancy and independent variable of less than 0.05; therefore, there is a significant effect. The *p*-values are shown in the last column. The determination coefficient $R^2$ was approximately equal to 0.3179 and adjusted $R^2$ was 0.3129, i.e., approximately 32% of the variability of the dependent variable, and the independent variable determines it. Figure 3 visualizes this output.

Figure 3 shows a declining relationship between innovation and the ratio of smokers over the age of 15 to the total population. It may be assumed that the higher the country's innovation potential, the lower the ratio of smokers over the age of 15 to the total population.

Correlation analysis was applied to complete the picture of the relations, the output is shown in Table 5. The table shows the outputs of the Royston test of multivariate normality, and this condition cannot be confirmed in any case. The Spearman's rank correlation coefficient ρ was applied, which determines a significant rela-

**Table 5.** Regression analysis – model 3

| Model 3 – F = 64.31(<0.001) $R^2$ = 0.32; $R^2$ adj. = 0.31 | Estimate | Std. error | *t*-value | Pr (> \|*t*\|) |
|---|---|---|---|---|
| (Intercept) | 37.64 | 2.54 | 14.79 | $< 2.20\times10^{-16}$ *** |
| GII | −0.37 | 0.05 | −8.02 | $4.07\times10^{-13}$ *** |

*Note: F* = 64.31(< 0.001); $R^2$ = 0.32; $R^2$ adj. = 0.31.



http://dx.doi.org/10.21511/im.16(2).2020.04

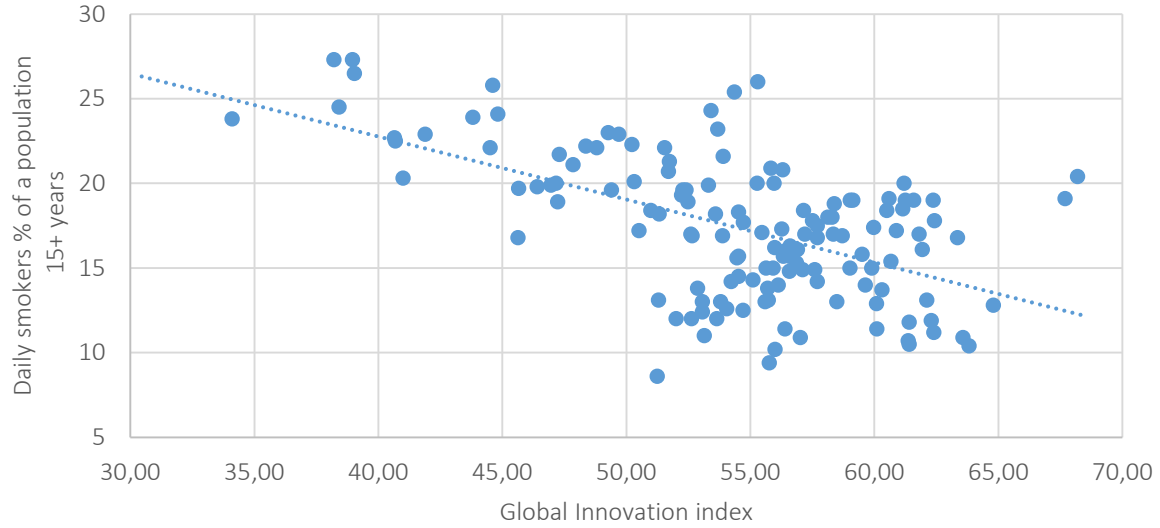


**Figure 3.** Relationship between GII and Smors_D%15

**Table 6.** Association analysis

| GII | G_Tob | Smors_D%15-24 | Smors_D%15+ |
|---|---|---|---|
| Royston MVN | 54.47 (< 0.001) | 15.49 (< 0.001) | 14.15 (< 0.001) |
| Spearman's ρ | −0.38 (< 0.001) | −0.26 (0.003) | −0.49 (< 0.001) |

tion in all analyzed cases. In all analyzed cases, there was a significant negative association, i.e., a decrease in smoking indicators can be associated with an increase in GII.

## 4. DISCUSSION

Several studies agreed that innovative activities reduce smoking (Reychav, McHaney, Hirak, & Merker, 2019). On the other hand, these researches are only at the micro level, i.e., at the individual level or specific innovation activities or technologies. The use of smartphones, apps, eHealth, mHealth, or QR codes to reduce smokers is widely discussed in many scientific studies (Hoeppner et al., 2016; Iacoviello et al., 2017; Peiris et al., 2019; Ali, Zhang, & Soomro, 2019; Borrelli, Bartlett, Tooley, Armitage, & Wearden, 2015; BinDhim, McGeechan, & Trevena, 2014). However, the macroeconomic view of the relationship between the country's innovation index and the country's overall smoking status is absent. Therefore, the macro-level research presented in this study was very difficult to relate to significant and relevant scientific sources of information. The present study showed that it is possible to talk about the effect of innovation (overall at the macro level – expressed by the GII index) on smoking in OECD countries. The rate of smoking is dependent on the innovation output of countries, i.e., less smoking in more innovative developed countries. The outputs of the relationship analysis indicate the existence of a significant negative correlation between innovation and selected smoking indicators. Thus, if smoking is reduced, an increase in innovation potential can be expected, and vice versa. Based on this, the efforts of public policies to promote a healthy lifestyle are also welcomed through effective marketing (Grier & Bryant, 2005). At the same time, the country's higher innovation potential can help reduce smoking. This study confirms the need to promote innovation in developed economies to reduce smoking. Marketing tools offer a wide range of tools that can help promote technological innovation (Danaher, Hardie, & Putsis, 2001), as well as modern smoking cessation technologies. In this way, it is possible to increase the country's innovation potential overall.

## CONCLUSION

This study reveals the relationship between innovation and smoking in developed countries. In both cases, marketing is an essential tool to promote the consequences of unhealthy habits, to support efforts to reduce smoking, as well as to support innovative smoking cessation technologies. The study's primary objective is to determine the effect of innovation on selected smoking indicators in a sample of OECD countries. Overall, the results show that the effect of innovation on the ratio of smokers over the age of 15 to the total population (model 3) may be considered as the relationship with the highest rate of significance. The effect of innovation on annual tobacco consumption per capita (model 1) is the second most significant relationship and the effect of innovation on the ratio of smokers over 15 and under 24 years to the total population (model 2) is the least significant when compared to the previous two models. All these relations may be considered as negative; thus, it may be assumed that with increasing innovation, smoking will decrease. The analysis of the relationship provided similar outputs. It is not possible to determine from the present research which innovative element affects smoking and its intensity. Therefore, it is very difficult to highlight any practical implications or recommendations. Future research in this field will focus on determining the effect of innovation on smoking from a specific perspective.

Overall, it is possible to confirm a demonstrable relation between innovation potential and smoking. Smoking is a negative factor affecting the economy, while the profits from the sale of tobacco products barely cover the costs of lost or limited productivity and treatment of smoking-related diseases. Innovations help reduce smoking. Thus, efforts to reduce this negative factor could be more pronounced directly to quit smoking, as well as indirectly – by increasing the countries' innovation potential. From this point of view, marketing plays an important role, which can effectively support and promote innovative technologies in the country. The limitation of this study is the nature of the innovation potential that indicates the countries' innovation activities relatively accurately, but generally. Also, not all data were available. Despite these limitations, the outputs can be considered as relevant. Future research in this area will focus on the perception of prevention activities by smokers and the analysis of the effectiveness of these activities. From a macroeconomic point of view, further research will focus on verifying the assumptions of the existence of relations between smoking-related indicators and selected macroeconomic outputs, such as competitiveness, productivity, or development.

## ACKNOWLEDGMENTS

This research is funded by the RVO 2020 internal grant scheme of the Tomas Bata University in Zlín titled "Economic quantification of marketing processes aimed at increasing value for the patient in the process of construction of system in order to measure and to manage performance in healthcare facilities in the Czech Republic."

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Funding acquisition: Beata Gavurova.
Investigation: Martin Rigelsky, Viera Ivankova.
Methodology: Martin Rigelsky, Beata Gavurova.
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Resources: Viera Ivankova, Jaroslav Gonos.
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http://dx.doi.org/10.21511/im.16(2).2020.04

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Writing – review & editing: Martin Rigelsky, Viera Ivankova, Beata Gavurova, Jaroslav Gonos.

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