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Tax evasion in the EU countries following a predictive analysis and a forecast model for Slovakia

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Keywords: *sustainable economic development; tax evasion; VAT gap; predictive statistical model; forecasting*

Abstract

Research background: Tax evasion is an urgent challenge for governments, as reaching sufficient level of tax revenues enable adequate sustainable economic development. The motivation for the research was thus the identification of the situation in the EU countries.

Purpose of the article: The main research objective was to identify the extent of tax evasion in the EU countries, with a subsequent specific focus on the econometric predictive models and a forecast of their future development in the case of Slovakia as the poorest performing country of the V4 in this area.

Methods: The research was primarily based on testing selected statistical indicators in the field of tax evasions expressed on the basis of the VAT gap. The data for the research was obtained from

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the EUROSTAT database and the international system VIES for the period between 2000 and 2017. In addition to panel graphs, the research hypotheses were tested primarily using a cluster analysis, t-test, time series analysis, and an analysis of the time series trend with 4 basic models: linear trend, quadratic trend, growth curve model, and S-curve model. On the basis of the Mean Absolute Percentage Error (MAPE), the S-Curve model was selected as the determining model of predicting tax evasion.

Findings & value added: Based on the results of the cluster analysis, the EU countries were divided into five reference groups by the VAT gap value, using the VAT gap percentage share on the overall GDP value. The research also provides a unique methodological framework and a unique econometric model for predicting the future VAT gap in Slovakia as the poorest performing country of the V4 in this area, which is applicable to other V4 and EU countries. The research results also enable policy-makers in the EU countries and specifically also in Slovakia and other V4 countries to compare themselves explicitly with the reference countries of the EU in terms of tax evasion and subsequently adopt adequate measures to improve the effectiveness and performance in this field.

Introduction

Tax evasion is an urgent challenge for many governments (Bucci, 2020; Mocanu, 2020; Herbain, 2018; Dobrovič *et al.*, 2017; Castro & Camarillo, 2014). Theoretically, in laboratory conditions, the following statement could be applied: tax revenues enable to ensure adequate infrastructure, health, education, culture, employment, social income distribution, and public safety. Furthermore, reaching a certain ethical and responsible commitment implies well-being, that is, the win-win situation when everyone wins: the company, the workers, and the society (Mamede de Andrade *et al.*, 2020; Nikulin, 2020). The question, however, is whether this statement can be applied to its full extent even in real the economic life.

Taxes are collected mainly because they represent the main financial resources for the functioning of the state. On the other hand, taxes and their payment have almost always been considered as “necessary evil” (Gallimore & Labro, 2015; Pezzolo, 2020; Sucahyo *et al.*, 2020); therefore, tax management is used to maximize companies’ corporate income (Peñaflor-Guerra *et al.*, 2020; Herbain, 2018; Thottoli, 2021). There are many cases when business entities illegally enrich themselves with taxes (Mažáry, 2014), which strongly contrasts with the desired sustainable economic development. In general, tax frauds (and mainly VAT frauds) then negatively affect the sustainability of economic development and many areas of economic and social life, such as insufficient government revenue, competition law infringement, or investing profits from illegal activities in other forms of crime (Popescu *et al.*, 2018).

The issue of tax fraud as a serious social and economic challenge of this time thus requires a complex and especially conceptual approach of all interested state bodies and other entities (Bucci, 2020; Mocanu, 2020; Srn-

ková, 2014). This extensive empirical research, its results and the recommendations specified in more detail in the following chapters of this paper aim to make a contribution to this goal.

The main objective of the research was to identify the extent of tax evasion in the EU countries using a wide range of quantitative statistical methods, with a specific focus on the creation of the econometric predictive model for the forecasting of the future trend of tax evasion on the case of Slovakia as the poorest performing country of the V4 in this area. On the basis of the results achieved, the authors try to make a contribution to the long-term sustainable economic development, in which the fight against tax fraud plays an important role.

The paper is divided into 4 main chapters. Chapter 2 presents the review of recent literature as a theoretical background of the research. Chapter 3 specifies the research objectives, research hypothesis, methodology, and data set. The most important research results are shown in Chapter 4, which is followed by their discussion in Chapter 5. In the conclusion of the paper, the limitations of the research are defined and the implications for public authorities and tax policy-makers in the EU and specifically in Slovakia are summed up.

Literature review

General overview of the tax evasion issue

The tax system is a decisive factor of economic progress and sustainable economic development (Mamede de Andrade *et al.*, 2020; Majerová, 2016; Arnold *et al.*, 2011). Tax collection represents an important instrument of ensuring state stability and economic development (Majerová, 2016; Brederode, 2009). It can also be used as a kind of instrument supporting business (Skica & Rodzinka, 2021). Ensuring compliance with tax laws is an enduring challenge for every government (Alm, 2021). On other hand, tax payment has always been considered as “necessary evil” (Pezzolo, 2020; Gallemore & Labro, 2015). Tax fraud and evasion thus negatively affect the economy and social life, as well as the sustainability of the economic development of every country (Alm, 2021; Bucci, 2020; Mamede de Andrade *et al.*, 2020; Majerová, 2016; Arnold *et al.*, 2011).

Each taxpayer has the right to arrange tax matters at their discretion (Cherian *et al.*, 2019). However, there is a difference between arranging tax matters at own discretion and intentional (illegal) tax evasion (Pezzolo, 2020; Armstrong *et al.*, 2015). In terms of tax collection, there are two dif-

ferent perspectives, where the state is interested in collecting as much tax as possible, while the taxpayer strives for paying as little as possible (Bucci, 2020; Pezzolo, 2020; Stieranka *et al.*, 2016; Brederode, 2009; Majerová, 2016).

Tax avoidance is one of the ways of legal tax reduction using the methods approved by tax office (Armstrong *et al.*, 2015; Gallemore & Labro, 2015; Pezzolo, 2020). Enterprises try to avoid tax payment by using all legal methods to reduce their tax burden, including tax exemptions, tax relief, tax loopholes, and the related legislation (Bucci, 2020; Herbain, 2018; Mocanu, 2020; Pezzolo, 2020; Armstrong *et al.*, 2015; Gallemore & Labro, 2015). Under certain circumstances, tax avoidance can represent a legal way to reduce tax liabilities. This is referred to as tax optimisation (Peñaflor-Guerra *et al.*, 2020). On the other hand, there are also illegal ways, which is tax evasion. Tax evasion is a complicated issue due to the fact that it cannot be eliminated only by changing legislation (see below); it thus represents a social and economic problem and an enduring challenge for government stakeholders. However, tax evasion is mostly “rewarded” by imposing penalties or fines rather than by qualifying it as a crime (Štiglic, 2017; Murray, 2019). A recent research study has proved that tax evasion is also related to the taxation rate (Majerová, 2016). The psychological limit of taxation is the limit to which an economic entity does not perceive or react negatively to the amount of tax. When this limit is exceeded, it may cause a resistance towards paying tax, which may result in illegal tax evasion (Murray, 2019; Široký, 2008; Herbain, 2018; Majerová, 2016). Therefore, for example Bucci (2020), in a recent study proposed the adoption of alternative methods to reduce tax evasion, such as presumptive taxation methods.

Based on an extensive analysis of the latest scientific publications, the decisive determinants that influence the occurrence and extent of tax evasion include the following factors: political tax evasion as an expression of disagreement with the politicians and governmental tax policy (Stieranka *et al.*, 2016); economic factors — tax evasion is also influenced by the degree of the economic development of the state (Andrejovská *et al.*, 2020; Dobrovič *et al.*, 2018); legislative — quality and stable legislation is necessary to eliminate and prevent tax evasions (Durán-Cabré *et al.*, 2018; Bucci, 2020); the level of tax burden and levies — inadequate or excessive tax burden increases the risk of speculations (Peñaflor-Guerra *et al.*, 2020; Andrejovská *et al.*, 2020; Majerová, 2016); taxation system (Bucci, 2020) as another key factor affecting tax evasion; social and ethical factors, where the reason of tax evasion can be low civic engagement in the area of tax payment and the level of corruption (Pezzolo, 2020; Gudiniavičius, 2020;

Stieranka *et al.*, 2016; Andrejovská *et al.*, 2020); control mechanism — tax control might be ineffective (Kot *et al.*, 2019), if there is a large disproportion between the number of taxpayers and the number of controllers (Stieranka *et al.*, 2016); globalization and technological and scientific development, where the rate of tax evasion increases with the technological development and modern IT technologies (Alm, 2021; Barbu, 2020); and an extremely important issue is double taxation, international tax evasion and tax havens (Rajnoha *et al.*, 2014).

There are also other important specific phenomena that influence the extent of tax evasion. According to Javorcik and Narciso (2008), there are different views on the effectiveness of presumptive policy tools in achieving different goals, such as the increase in voluntary tax compliance, the growth of tax revenues, and the reduction of shadow economy and tax evasion (Javorcik & Narciso, 2008). Furthermore, Javorcik and Narciso (2008) found that tax evasion elasticity is higher for differentiated products, mainly through misrepresentation of prices. Mishra *et al.* (2008) show that evasion elasticity is lower for products with easier enforcement. Their results imply that there is a causal relationship between enforcement and evasion.

Recent scientific research also showed that the tolerance of tax evasion contributes to its further increase (Durán-Cabré *et al.*, 2018; Pezzolo, 2020; Bucci, 2020). The results of the research conducted on a representative sample of 1,500 randomly selected respondents (taxpayers) within Slovakia provided important findings and conclusions claiming that up to 88.17% of the respondents tolerate tax evasion (Kot *et al.*, 2019).

Previous research studies conducted in the EU countries

It follows from the above section that one of the most important issues for governments in terms of sustainable development of the economy is the tax system and the tax gap, which play an important role in ensuring sustainable economic development (Bucci, 2020; Andrejovská *et al.*, 2020; Harutyunyan, 2017; Dabla-Norris *et al.*, 2017; Castro & Camarillo, 2014; Zídková, 2014; Arnold *et al.*, 2011; Brederode, 2009). According to Andrejovská *et al.* (2020), there is a dependence between the VAT gap and tax rates. Majerová (2016) distinguishes the VAT gap on three key variables: Corruption Perception Index CPI, GDP growth rate, and the basic VAT rate.

Table 1 shows the result of the latest study, which determines the estimated extent of tax evasion in the EU. The study was conducted by an in-

dependent external organization and published by the European Commission in November 2020.

The results presented within this study (see Table 1) include tax evasion as well as the data on non-payment of taxes as a result of secondary insolvency and legal tax avoidance (European Commission, 2020). The results of the study are alarming and represent an enduring challenge, point to the significant differences between the EU member states in terms of the overall extent of tax evasion. However, it is also natural and logical that there are fundamental differences among EU countries in this area. As Table 1 preliminary shows (see year 2019), the old EU member states are mostly better performing than the new mostly post-communist countries that joined the EU later. The best performing countries, which reach a rate of up to 10%, are mainly the old member states such as Austria, Denmark, Finland, Germany, Luxemburg, the Netherlands, or Sweden. Malta and Cyprus also achieve surprisingly very good results. On the other hand, there are countries that achieve very poor results with a rate of up to 30%, such as Croatia, Greece, Italy, Lithuania, Latvia, Romania, Slovakia, and Spain. Among the average performing countries (the rate from 10% to 30%) there are other EU countries (both old and new EU member states).

Some other research studies have been provided in the past years. Andrejovská *et al.* (2020) analysed the tax evasion in the EU during the period of years 2004–2017 by using a regression model. The results showed that tax gaps in the EU member states have been growing every year. Other recent research of tax evasion and the tax gap in the EU countries for the period between 2011 and 2019 were realized recently by Kowal and Przekota (2021). The efficiency of VAT collection in the EU countries was modelled using a square function, determining the significance of the parameters of this function. This research also shows a positive correlation between the value of the basic VAT rate and the tax gap, concluding that in the countries with a higher standard VAT rate and a greater number of preferential rates, the tax gap is greater. Similar research in the EU countries was provided by Zídková (2014). The main purpose of this research was an analysis of potential variables explaining the VAT gap in the EU member states in two selected years (2002 and 2006) by using a regression model. According to Kasnauskienė and Krimisieraitė (2015), recent statistical data shows that new member states have on average a nine percent higher VAT gap than the older members of the European Union. However, the main purpose of this study was to identify the determinants significantly influencing the size of the VAT gap only in specific conditions of Lithuania, using the MIMIC method for quarterly data of the period between 2000 and 2013. These studies conducted on the case of the whole EU or only

partially in an individual EU country differ both in the methods used and also in the research period data included in the research. Moreover, these studies focus only on the analysis of the past and there is no specific prediction model of the future development.

As it can be preliminary seen from the above, the tax gap differences among EU countries are very large and their deeper research clearly deserves attention. Not only that especially the old EU member states belong to the better countries (this is a natural phenomenon, as most of them are economically highly developed countries with a high GDP per capita), but we can also observe highly abnormal differences, for example in the V4 Group. The V4 is a group of four countries representing the new EU member states (Czech Republic, Hungary, Poland, and Slovakia). In general, it represents a homogeneous group of countries with similar historical, economic, social, and also political development in the past. However, despite this fact, it is surprising that there is a large difference between Slovakia and other three V4 countries in this researched issue (see Table 1). Slovakia (36%) achieves significantly poorer result than Poland (15%), Czech Republic (25%), or Hungary (26%).

From the above mentioned, a real research problem and a gap arise and deserve attention in further research. The basic and at the same time a challenging research question is: How can the EU try to achieve a common tax policy when even the relatively homogeneous V4 group countries is far from the same level of performance in this area? This was our main motivation for an extensive scientific research of the given issue. The results of the research are presented in more detail in the following chapters.

Research methodology

The main research objective was to identify the extent of tax evasion in the EU member states with a subsequent specific focus on the analysis of the past and the creation of the econometric predictive model for the forecasting of the future trend of tax evasion in the specific conditions of the Slovak Republic.

The research was primarily based on testing selected statistical indicators concerning tax evasion and specific tax evasion in the EU countries. Tax evasion expressed as the VAT gap is a dependent variable. The analysed tax evasion is analysed in relation to the VAT gap in two following monitored dimensions of the research: in absolute terms — the VAT gap expressed in millions of euros; and in percentage terms — the percentage

share of the VAT gap on the overall GDP. In both cases, the same period of 18 years was analysed (2000–2017).

For the analysis of their past development, panel graphs were used in both cases. When examining the similarity of the individual EU countries in terms of the size of the VAT gap as its percentage share on the total GDP, a cluster analysis was used as a method of multidimensional inductive statistics. The Euclidean distance of unweighted averages of groups was used in creating the dendrogram. Despite the possibilities of an exact determining an individual country into a specific cluster, we based their incorporation also using a qualitative analysis (measures such as adoption of law against tax evasion of the country and other measures adopted in the real world have been considered), so that the inclusion of countries in the cluster is of a logical significance. The result of the Amalgamation Schedule approach was used as a guideline for the inclusion of a country in the relevant cluster, where we evaluated a logical interconnection.

The inductive research hypotheses were formulated in accordance with the aforementioned objective as follows:

H1: The VAT gap in Slovakia is larger than the average VAT gap in other EU countries.

H2: The change of the VAT gap in Slovakia in the past has had a downward trend.

The research data were obtained from the EUROSTAT database and the international system VIES [*European Commission. The Concept of Tax Gaps: Report on VAT Gap Estimations, FISCALIS VAT gap Project Group (FPG/041), 2017. <https://ec.europa.eu/info/statistics/search-eurostat-statistics.sk>](ec.europa.eu). The VIES system provides information on the mutual trade volume of the EU countries within the EEC. The Eurostat database contains all statistics obtained from national statistical offices of 28 member states of the EU (including the UK).*

The research hypothesis H1 was tested by using an individual *t*-test. The basic prerequisite for using an individual *t*-test is the normal Gaussian distribution of the dataset. On the basis of the achieved significance value in the Shapiro-Wilk normality test $p = 0.085$, it can be stated that the data were obtained from the normal Gaussian distribution at the chosen significance level of $\alpha = 5\%$; the basic prerequisite for the use of an individual *t*-test was met. The test statistics of the individual *t*-test has the following form:

$$t = \frac{\bar{x} - \mu_0}{s} \cdot \sqrt{n} \quad (1)$$

The second research hypothesis (H2) was examined by using the time series analysis and the time series trend analysis. The time series consists of values that are gathered, recorded or monitored over time (arranged in chronological order). However, this does not mean that time is the only independent variable on which the values depend. The explanatory variable (i.e. the variable whose changes influence the time series behaviour) may have different values. Such values can be considered the explanatory variable for the time series. The time interval between individual observations was assumed to be constant, i.e. a discrete time series with equidistant time steps was used. The discrete time series consists of an organized data set (x_1, \dots, x_n, \dots) obtained in the same time interval, where x_t is a real number. The main purpose of the time series analysis was to understand the basic mechanism according to which the monitored values are generated and to predict their future values. The authors assumed that the generating mechanism is random, i.e. the time series (x_1, \dots, x_n, \dots) is a realization of the stochastic process (X_1, \dots, X_n, \dots) , where each X_t is a random variable with its probability distribution, and x_t represents one value of this random variable. The overall number of values in the time series is called the time series length, and is marked as n . The time series where the value of just one symbol (x_1, \dots, x_n, \dots) is monitored in time t is referred to as a univariate time series. If the value of more parameters (e.g. $k > 1$) is monitored in time t , the result is a time series whose individual components are k -dimensional vectors, which is referred to as a multivariate time series. In the research, it was also assumed (and applied) that each stochastic process $\{X_t, t \geq 0\}$ can be expressed by using its specific characteristics:

1. Mean value: $\mu_t = E(X_t)$
2. Variance: $\sigma_t^2 = D(X_t) = E(X_t - \mu_t)^2$
3. Skewness: $\mu_t^{(3)} = E(X_t - \mu_t)^3$
4. Kurtosis: $\mu_t^{(4)} = E(X_t - \mu_t)^4$

5. Covariance function: $\gamma(r, s) = E[(X_r - \mu_r)(X_s - \mu_s)]$

6. Correlation function: $\rho(r, s) = \frac{\text{cov}(X_r, X_s)}{\sqrt{D(X_r)}\sqrt{D(X_s)}}$

A special case of stochastic processes are stationary stochastic processes. A stochastic process $\{X_t, t \geq 0\}$ is considered as strictly stationary if its statistical characteristics do not change over time (i.e. probability distribution is invariant in time). Since strict stationarity is hard to verify in practice, weak stationarity is considered sufficient. A stochastic process $\{X_t, t \geq 0\}$ is weakly (covariance) stationary if:

1. $\mu_t = E(X_t) = \mu$; $\sigma_t^2 = D(X_t) = E(X_t - \mu_t)^2 = \sigma^2$ for $t = 1, \dots, n$
2. $\gamma(r, s) = \text{cov}(X_r, X_s) = E[(X_r - \mu_r)(X_s - \mu_s)]$ is a function $(s - r)$,

i.e. it depends only on the distance of X_s, X_r over time, not on their position on the timeline. The difference $(s - r)$ is called displacement, and is marked as k . The time series as one realization of a stochastic process $\{X_t, t \geq 0\}$ is thus weakly (covariance) stationary if its basic statistical characteristics (mean value and variance) remain constant throughout the whole time series. A stationary time series is evenly balanced (i.e. with constant variance) at the constant level (i.e. it has a constant mean value), where the dependence (correlation) between two random observations depend only on their mutual time distance (that is, on the number of time intervals k between them) and not on their actual position in the time series (i.e. on t).

Research results

In terms of the absolute VAT gap expressed in millions of euros, its average value in the EU countries for the period between 2000 and 2017 is 5,291.42 million EUR. The smallest VAT gap (11) was recorded in Cyprus; the largest VAT gap in millions of euros (40,424) was recorded in Italy.

The value of the lower quartile is 639, upper quartile is 4,417. It can be said that in the EU countries in the period between 2000 and 2017, 50% of all values of the VAT gap expressed in millions of euros are within the interval between 639 and 4,417.

It follows from Figure 1 that the highest values of the VAT gap expressed in millions of euros in the monitored period between 2000 and 2017 were recorded in Italy. The average VAT gap expressed in millions of euros in the monitored period is $33,171 \pm 2,410.8$ with the standard deviation of 5220. The result of the Shapiro-Wilk normality test ($p = 0.465$) shows that at the significance level of $\alpha=0.05$, the size of VAT gap in Italy has a normal Gaussian distribution. The minimum value of the absolute size of VAT gap is 22,819, while the maximum value is 40,424. 50% of all values are within the interval between 29,357 and 37,044.

In terms of the percentage share of the VAT gap on the overall GDP value in the EU countries in the monitored period its average value is 1.442% (see Figure 2). The largest VAT gap in the EU countries was recorded in Romania, with the average value of 4.803%, followed by Lithuania (with the average value of 3.685%) and Greece (the average value is 3.043%).

On the other hand, the smallest VAT gap as a percentage share on the total GDP was recorded in Cyprus (0.070%), Croatia (0.256%), and Sweden (0.341%).

In terms of VAT gap in the EU countries under review, Romania stands out, with the average VAT gap in the monitored period being $4.8 \pm 0.321\%$, with a standard deviation of 0.696%. The smallest VAT gap as a percentage share on the overall GDP is 3.415% recorded in the last year of the monitored period (2017). The largest VAT gap as a percentage share on the total GDP was achieved in 2009 (6.094), two years after its accession of the EU. The value of the lower quartile of the VAT gap as a percentage share on the total GDP is 4.46%; the value of the upper quartile is 5.19%.

VAT gap reference groups in the EU countries through cluster analysis exploration

In terms of the similarity in the size of the VAT gap in individual EU countries as a percentage share on the GDP in the monitored period between 2000 and 2017, Figure 3 shows the results of the cluster analysis method.

It follows from Figure 3 that the EU countries can be divided into several groups by the size of the VAT gap. The first group with a similar size of VAT gap includes Austria ($0.854 \pm 0.075\%$), Germany ($0.887 \pm 0.043\%$), United Kingdom ($0.826 \pm 0.108\%$), Belgium ($0.977 \pm 0.073\%$), Denmark ($1.050 \pm 0.061\%$), Finland ($0.922 \pm 0.164\%$), France ($1.009 \pm 0.141\%$), Estonia ($1.241 \pm 0.222\%$), and Portugal ($0.899 \pm 0.212\%$). The values of the VAT

gap as a percentage share on the total GDP of these countries are within the interval between 0.800% and 1.299%. The second important group of countries with a similar size of the VAT gap includes Ireland (0.647±0.134%), Slovenia (0.600±0.100%), Spain (0.586±0.229%), Luxembourg (0.501±0.139%), Netherlands (0.447±0.098%) and Sweden (0.341±0.058%). The values of the VAT gap as a percentage share on the total GDP are within the interval between 0.300% and 0.790%. The third group which shows the smallest VAT gap according to Figure 3, includes Cyprus (0.070±0.032%) and Croatia (0.256±0.118%). This group of countries with the smallest VAT gap as a percentage share on the total GDP is defined by the interval between 0.000 % and 0.299 %. The countries with larger VAT gap expressed as a percentage share on the total GDP include Bulgaria (1.946±0.401%), the Czech Republic (1.690±0.259%), Poland (1.547±0.321%), Latvia (2.084±0.451%), Greece (3.043±0.287%), Hungary (2.483±0.228%), Italy (2.139±0.103%), Slovakia (3.036±0.242%), and Malta (1.812±0.744%). Those countries are included in the fourth group, and the values of VAT gap are within the interval between 1.800% and 3.599%. The fifth group of countries with a similar size of VAT gap as a percentage share on the total GDP include Lithuania (3.685±0.358%) and Romania (4.803±0.322%). This last group shows the highest percentage share of the VAT gap on the total GDP, with its values achieving 3.600% and more.

Within the testing of research hypothesis H1, Table 2 shows that according to the results of this extensive research, the average size of the VAT gap of the EU countries in the period between 2000 and 2017 (except for Slovakia) is 1.3831% with a standard deviation of 1.2161%. The standard error of the arithmetic mean has the value of 0.0552%; the value of the arithmetic mean of the VAT gap as a percentage share on the total GDP of the EU countries at the 95% confidence interval is thus 1.3831 ± 0.0282 [%].

The results shown in Table 2 as well as additional analyses presented in Figure 4 show that at the chosen significance level of $\alpha = 5\%$ and based on the achieved value of the t – test $p = 0.000$, the first research hypothesis H1 can be confirmed.

Diagnostic results of the verification of testing of the first research hypothesis H1 are also presented in Figure 5. Based on this analysis, if the actual mean size of the VAT gap of the EU countries in the monitored period of 2000–2017 is by 0.10488% lower than the average value of the VAT gap of Slovakia in the monitored period, which is 3.063% in this case, there will be 60% probability of detecting a significant difference. If the actual value of the arithmetic mean of the VAT gap is by 0.16165% lower than

the mean value of the VAT gap of Slovakia in the monitored period, which is 3.063%, the probability of detecting a significant difference will be 90%.

Econometric model of the tax evasion predicting for Slovakia

The analysis of the time series trend (research hypothesis H2), i.e. the annual change in the percentage share of the VAT gap on the total GDP conducted in the specific conditions of Slovakia in the period between 2000 and 2017 is shown in Figures 6–9. Four basic models were used in the estimation of the trend of the annual change in the VAT gap: linear trend, quadratic trend, growth curve model, and S-curve model.

The mean value of the residuals, i.e. the difference between the actual percentage share of the VAT gap on the total GDP of Slovakia in the case of a linear trend is 0.07952%. The minimum value of residuals in the case of the linear trend is -0.7952%, while the maximum value is 0.72820%. The margin of the residuals is 1.48014%. In the case of a quadratic trend, the mean value of the residuals is 0.08528%, with the margin of 1.45248%. The minimum value of the residuals is -0.78575%, while the maximum value is 0.66673%. The third model of the analysis of the VAT gap trend is a growth curve model. The mean value of the residuals in the case of this model is 0.11450%, with the margin of the residuals of 1.49071%. The minimum value of the residuals is -0.71880%, while the maximum value is 0.77192%. The last analysed trend is the S-Curve model, in which the mean value of the residuals is 0.00208%, with the margin of 1.34741%. The minimum value of the residuals is -0.64854%, while the maximum value is 0.69887%. Another criterion in selecting the final trend of the annual change in the percentage share of the VAT gap on the total GDP of Slovakia in the period of 2000–2017 is the value of the Mean Absolute Percent Error (MAPE). From the perspective of this value, the minimum level of this criterion at the level of 10.1412 was achieved in the case of the fourth analysed trend — S-curve model. Graphical representation of the individual models' residuals within the individual years is shown in Figure 10.

Based on the aforementioned analyses of trends of the annual change in the percentage share of VAT gap on the total GDP of Slovakia in the period between 2000 and 2017, i.e. the minimum value of the mean value of the residuals, the minimum value of the margin, and the minimum value of MAPE, the last analysed trend — the S-Curve model (see Figure 9) was chosen as the determining model. For the specific time series, the chosen model can have the following form:

$$Y_t = \frac{1}{31.4966 + 0.038387 \cdot (1.38667^t)} \quad (2)$$

Based on the analysis of the chosen trend of the annual change in the percentage share of the VAT gap on the total GDP of Slovakia in the monitored period, which is presented in Figure 9, and based on equation (2), it can be stated research hypothesis H2 was confirmed, which means that the VAT gap shows decreasing trend. This is also confirmed by the predicted development of the trend of the change in the share of the VAT gap on the total GDP of Slovakia for the years between 2018 and 2022 (see Figure 9). The predicted value of the share of the VAT gap on the total GDP of Slovakia in the year 2022 on the basis of the model applied (2) is 1.0649%. However, it should be noted that all four applied models confirm a gradual decrease in the VAT gap of Slovakia, but with different dynamics.

Discussion

Based on the extensive research, several important conclusions and recommendations to policy-makers in the EU, individual EU countries, as well as in the specific case of Slovakia can be proposed.

On the basis of the cluster analysis (Figure 3), the EU countries can be divided into five groups by the value of the VAT gap. *Countries with the minimum extent of tax evasion* — include the countries in which the share of the VAT gap on the total GDP ranges between 0.000% and 0.299%, e.g. Cyprus and Croatia. This finding is contrary to the recent study conducted by Andrejovská *et al.* (2020). This may be due to a different period of data that were included in the research, also different research methods that were used. *Countries with a low extent of tax evasion* — this group includes the countries in which the share of the VAT gap on the total GDP ranges between 0.300% and 0.799%, e.g. Ireland, Slovenia, Spain, Luxembourg, the Netherlands and Sweden. *Countries with a medium extent of tax evasion* include the countries in which the share of the VAT gap on the total GDP is within the interval between 0.800% and 1.299%, specifically Austria, Germany, United Kingdom, Belgium, Denmark, Finland, France, Estonia, and Portugal. These findings are also contrary to the recent extensive study conducted by Andrejovská *et al.* (2020), who concluded that the highest tax evasion during the observed period (2004–2017) was in Germany, France, United Kingdom, and Italy. *Countries with a large extent of tax evasion* include the countries in which the share of the VAT gap on the

total GDP ranges between 1.800% and 3.599%, specifically Bulgaria, the Czech Republic, Poland, Latvia, Greece, Hungary, Italy, Slovakia, and Malta. *Countries with an extremely large extent of tax evasion* include the countries in which the share of the VAT gap on the total GDP exceeds 3.600%, namely Lithuania and Romania. In the case of Lithuania, the results of the recent study by Andrejovská *et al.* (2020) are contrary to our findings. This may be due to a different period of data that were included in the research, even also different research methods that were used. On the other hand, the findings of our research appear to be in accordance with the findings of this study, which claims that the VAT gap increases with the growing corruption index.

Our findings are not comparable with the study provided recently by Kowal and Przekota (2021), which, although it classified the EU countries similarly into 6 categories, it did so according to the VAT gap reduction trend in the past period. The research study provided by Kasnauskienė and Krimisieraitė (2015) was also realised only in the case of an individual country Lithuania. Similar research conducted in the EU countries by Zídková (2014) was implemented only in two selected years (2002, 2006), therefore the results achieved are not sufficiently comparable with our study.

On the basis of the results of the testing of the research hypotheses (H1, H2), it can be stated that the research confirmed the validity of both hypotheses. In the case of research hypothesis H1, on the basis of the result of the individual *t*-test ($p=0.000$) (see Table 2, Figure 4), it can be stated that the VAT gap in Slovakia is larger than the average VAT gap of the EU countries at the chosen significance level of $\alpha = 0.05$. In the case of research hypothesis H2, tested by using a time series analysis and a time series trend analysis (see Figures 6–9), a model of time series was created defined by formula (2), which confirms that the percentage share of the VAT gap on the total GDP of Slovakia in the period observed shows a downward trend. Research hypothesis H2 was thus confirmed: On the basis of the formula (2), in the specific conditions of Slovakia a downward trend of the VAT gap was predicted until the year 2022, with the value reaching up to 1.0649%, by which Slovakia would achieve similar values as the countries with *the medium extent of tax evasion* (Austria, Germany, United Kingdom, Belgium, Denmark, Finland, France, Estonia and Portugal). Unfortunately this unique result cannot be compared to any previous research. In the future, this prediction could be verified in further research, which is planned in a time horizon of about 3 years.

However, it is necessary to state that despite efforts of the current government of Slovakia in the tax collection, its measures cause an increase in

the public deficit and the state debt. One of many consequences of a stabilization process is likely to be an increase of the tax rate, which despite measures taken in the fight against tax fraud may increase the level of the tax gap. The described trend is based on the assumption that no significant changes will occur in the predicted period. There are a number non-predictable and random effects that can significantly change the prediction itself, and therefore the trend created must be understood only as a theoretical prediction construct usable in the further research.

Conclusions

Tax evasion is an urgent challenge for many governments in their effort to ensure sustainable economic development.

On the basis of own research and its results, a methodological, theoretical and practical reference framework was created in the field of the VAT gap and its prediction model, so that it is possible to verify its validity in the actual economic life of the EU countries and specifically of Slovakia as the poorest performing country of the V4 in the near future. A unique theoretical tax gap prediction construct proposed in the research provides a new both theoretical and practical knowledge and tool usable in this area. We believe that thus we have fulfilled the research gap defined in the Literature review section. It can help to policy-makers, which can use this to adopt uniform rules and a reference framework for an effective fight against the tax evasion in the individual EU countries as well as across the EU. The combining of this research with the previous research enables us to create an even more complex model of the tax evasion management in the future, which could include both macroeconomic and non-macroeconomic factors. Using the methodology proposed and applied in this research, the further research can focus on predicting the development of the tax gap in Slovakia as well as in the aforementioned reference countries in the EU. This prediction can be subsequently compared with the real development of the VAT gap.

The authors are also aware of the fact that despite their findings and recommendations, sustainable development of a country does not depend only on the reduction of the tax gap and tax evasion; it also depends on the absolute volume of tax revenues and their effective use for covering the costs of public goods and services in a given country. In addition to tax evasion, the growth of the country's GDP and increased tax revenues are affected by the structure of the GDP, taking into account global phenomena, such as transfer pricing and the outflow of profits into tax havens, or the

emerging phenomenon of digital economy and the technical issues related with its taxation. However, this is already beyond the scope of the research presented in this paper.

A limitation of the research that needs to be pointed out is the fact that in addition to the economic development expressed in the form of GDP, the extent of tax evasion depends on many other factors. We should state that the level of the tax gap itself is a parameter that depends on a large number of factors and measures adopted by policy-makers in the real world including the tax rate, and a change in any of them can cause a significant change in the predicted value. However, the basic idea of the research was to create a prediction model to estimate the future development of the level of the tax gap in compliance with specific measures adopted in the real world. Moreover, the free movement of goods, services, people, and capital in relation to the creation of the EU internal market causes that the EU member states have to deal with ever increasing number of tax frauds. For example, also the collection of the VAT as the most important item in the overall tax collection largely depends also on the discipline the taxpayers, which is also conditioned by many non-economics factors in the form of efficiency and performance of tax management of the country (Harutyunyan, 2017; Dabla-Norris *et al.*, 2017; Dobrovič *et al.*, 2018; Kot *et al.*, 2019). The research results are also limited in terms of the used research data, which were mostly obtained from the Eurostat database.

Despite these limitations, the research results provide a possibility for the policy-makers in the EU countries and specifically in Slovakia to compare the situation concerning the tax evasion with the individual EU countries and to adopt measures to improve the efficiency and performance in this field. In the case of Slovakia, on the basis of the research results, the authors of this paper recommend the comparison with the so-called reference countries included in the group of countries showing the medium extent of tax evasion, such as Austria, Germany, United Kingdom, Belgium, Denmark, Finland, France, Estonia, and Portugal, into which Slovakia might be included in a time horizon of 3 years. Within this comparative process and on the basis of the previous scientific studies (Dobrovič *et al.*, 2018; Kot *et al.*, 2019), it is recommended to include also many non-macroeconomic factors in the form of a proposed model of efficiency and performance of the tax or financial management of individual countries with which Slovakia will be compared.

Moreover, based on the above mentioned, in the future research another challenge appears on how to modify a proposed prediction model in the conditions of the further tax harmonization planned across the EU, whereas

based on previous research it is evident that the level of the tax rate significantly affects the tax gap.

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Annex

Table 1. Tax evasion in EU Member States expressed as a share of total tax liability in % and tax evasion in 1.10⁶ euros

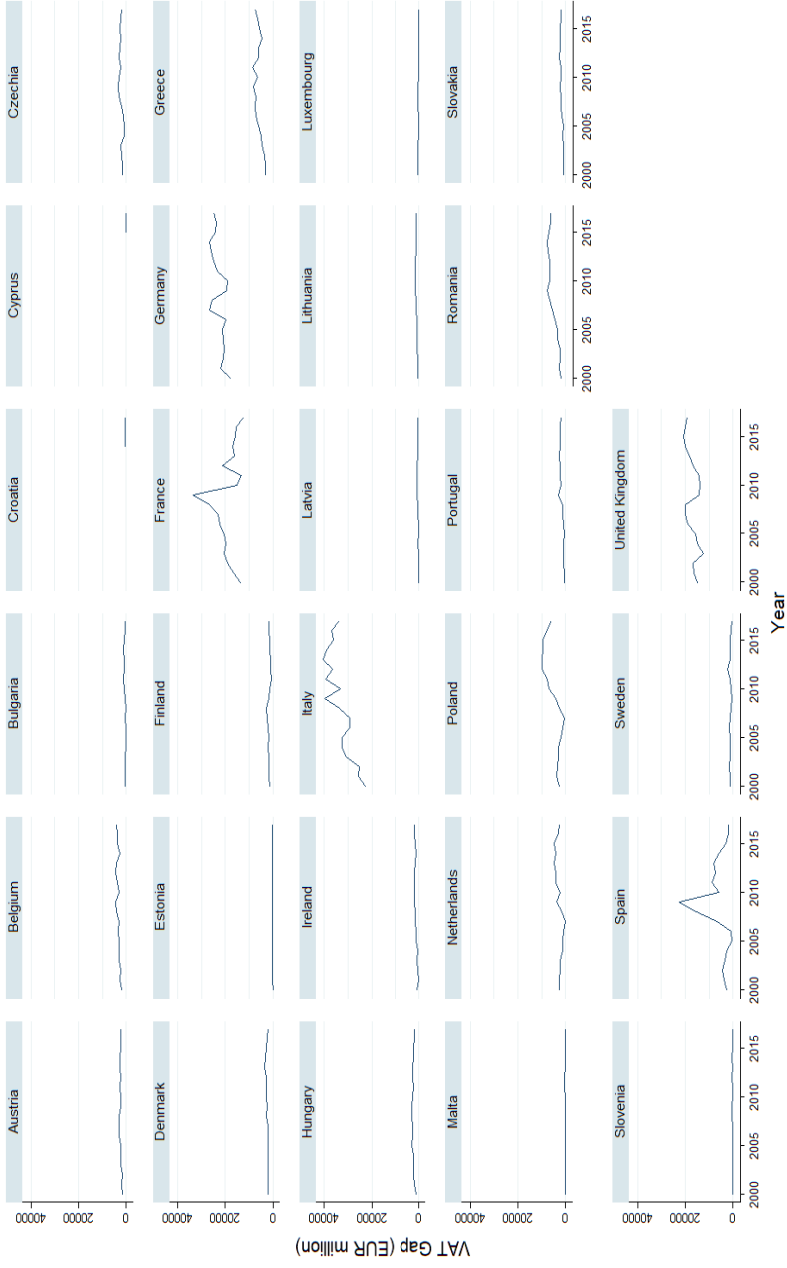
EU States	Year 2017		Year 2018		Year 2019	
	%	Sum	%	Sum	%	Sum
Austria	10	2 776	13	3 868	9	2 452
Belgium	15	4 476	16	5 370	16	4 691
Bulgaria	10	483	25	704	15	754
Cyprus	7	316	6	267	8	346
Czech Republic	29	4 617	28	4 446	25	3 831
Croatia	29	2 220	27	1 985	31	2 509
Denmark	9	2 582	10	2 886	9	2 464
Estonia	15	321	18	361	13	282
Finland	15	3 362	14	2 937	10	1 926
France	19	32 348	19	32 633	20	33 468
Germany	13	26 144	12	26 909	10	19 587
Greece	31	7 531	39	9 962	35	8 569
Hungary	28	3 654	30	3 796	26	2 976
Ireland	11	1 396	10	1 198	15	1 913
Italy	25	31 887	27	36 634	31	39 983
Lithuania	37	798	41	996	42	864
Latvia	36	1 363	36	1 462	40	1 497
Luxemburg	17	704	17	691	8	324
Malta	9	65	4	31	10	73
Netherlands	3	1 755	9	4 102	9	3 958
Poland	12	3 852	15	5 610	15	3 995
Portugal	16	2 765	16	2 964	20	3 411
Romania	48	8 987	48	10 648	49	7 830
Slovakia	38	2 624	37	2 774	36	2 695
Slovenia	10	386	10	345	11	392
Spain	16	12 783	21	16 596	34	23 484
Sweden	1	345	2	986	2	588
UK	13	17 337	13	19 986	13	14 655
EU average	18.6	6353	20.1	7184	20.1	6768

Source: own elaboration according to ec.europa.eu.

Table 2. Results of testing research hypothesis H1

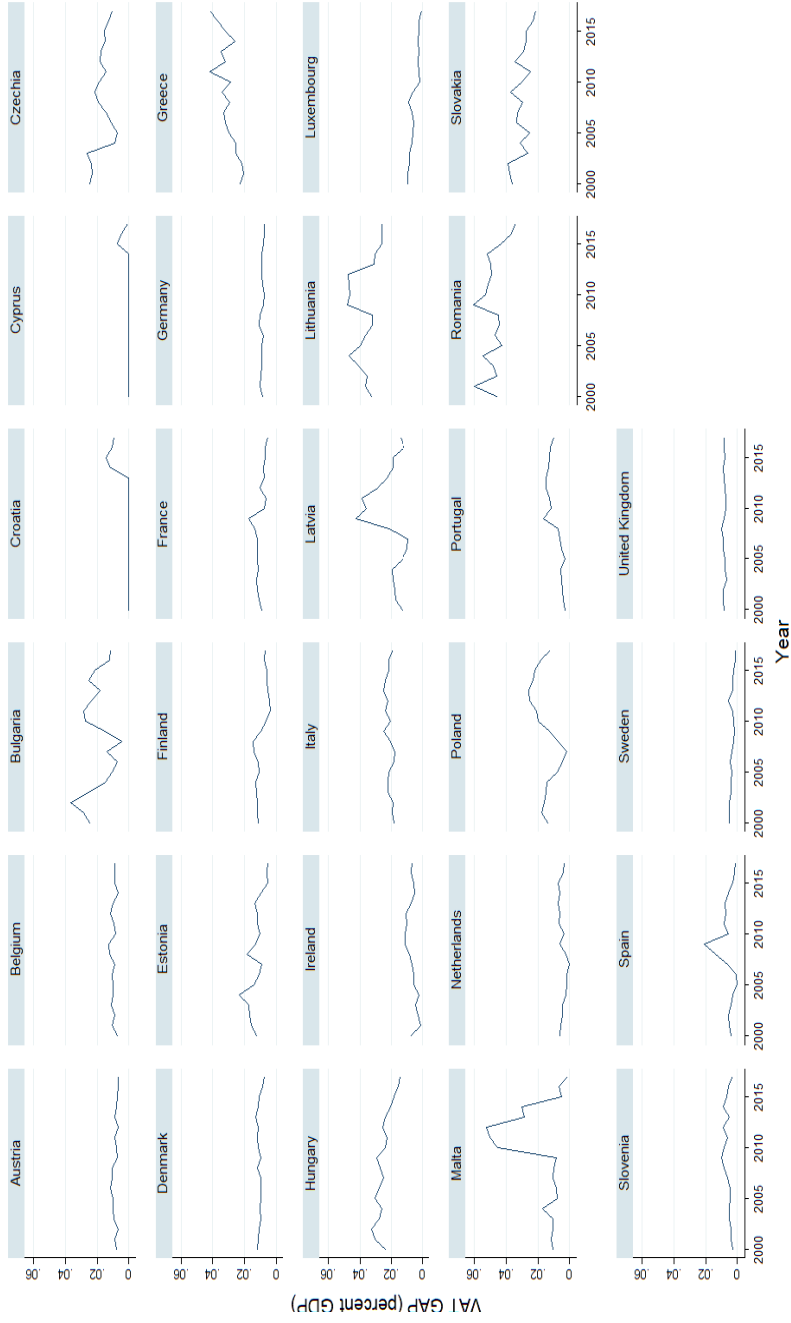
N	Mean	StDev	SE Mean	95% Upper Bound for μ	t-Value	p-Value
486	0.013831	0.012161	0.000552	0.014740	-29.96	0.000

Figure 1. Panel graph of absolute VAT gap in EU countries between 2000 and 2017



Graphs by Member state

Figure 2. Panel graph showing percentage share of VAT gap on the total GDP of EU countries between 2000 and 2017



Graphs by Member state

Figure 3. Dendrogram of VAT gap as a percentage share on the total GDP of EU countries between 2000 and 2017

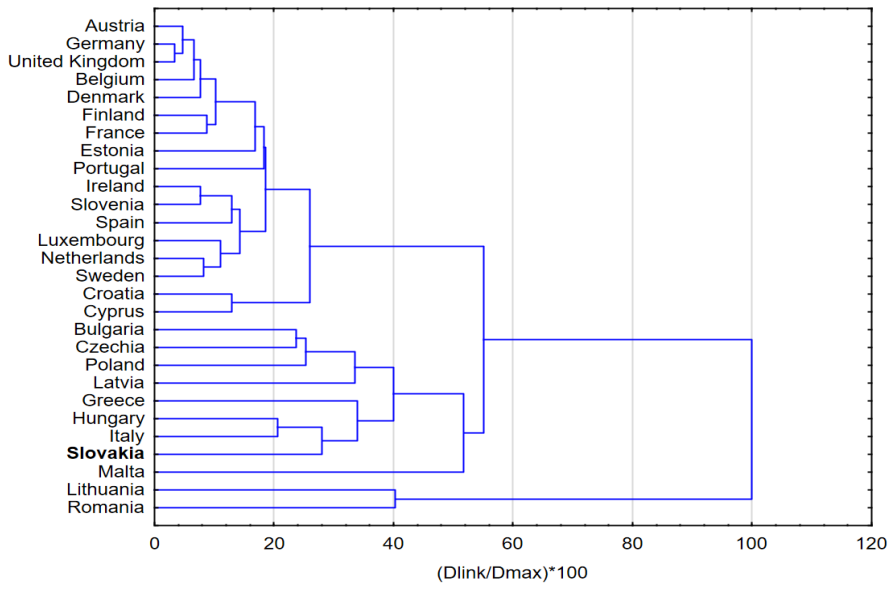


Figure 4. Graphical verification of results of testing research hypothesis H1

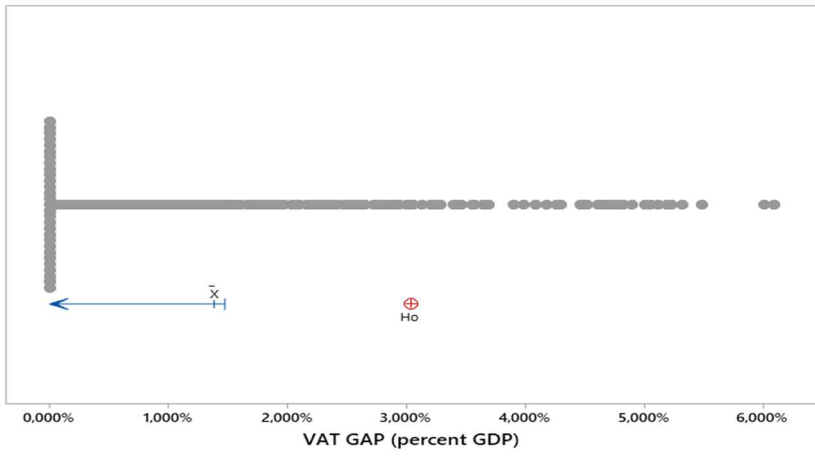


Figure 5. Diagnostic report of results of testing research hypothesis H1

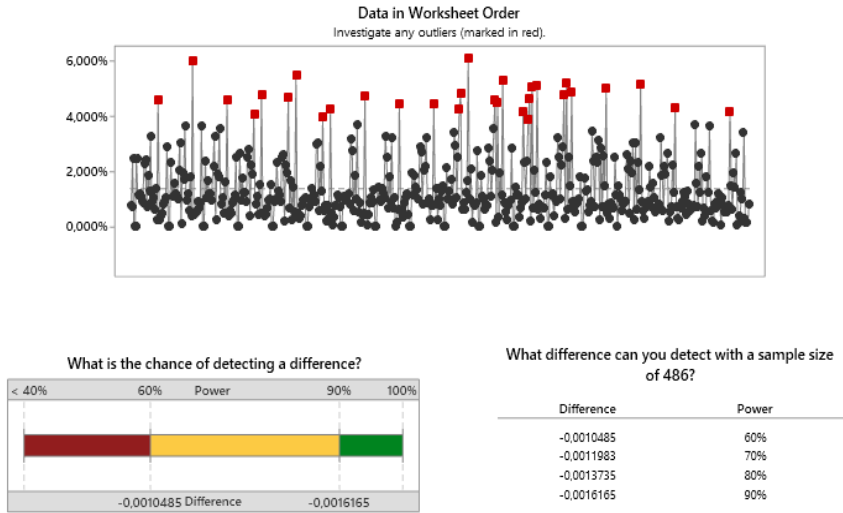


Figure 6. Linear trend of annual change in percentage share of VAT gap on the total GDP of Slovakia

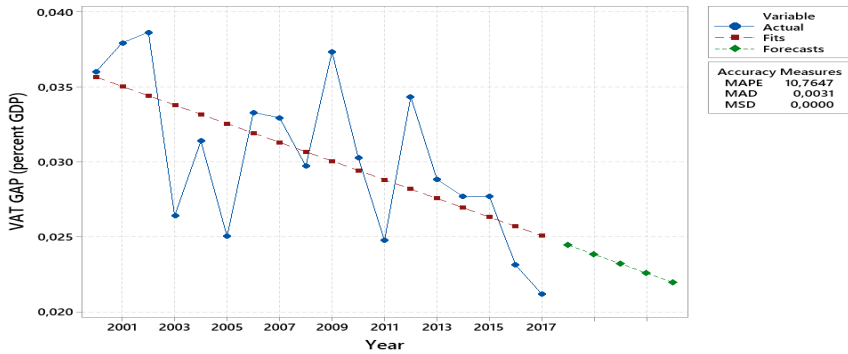


Figure 7. Quadratic trend of annual change in percentage share of VAT gap on the total GDP of Slovakia

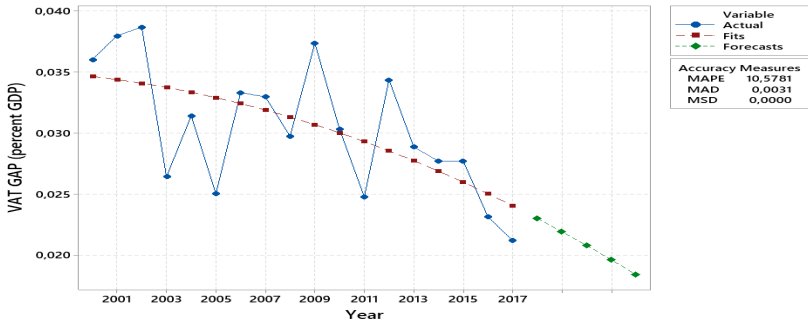


Figure 8. Growth curve model of annual change in percentage share of VAT gap on the total GDP of Slovakia

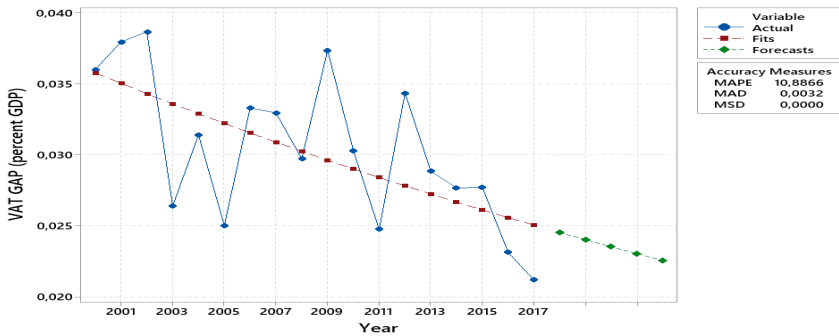


Figure 9. S-curve model of annual change in percentage share of VAT gap on the total GDP of Slovakia

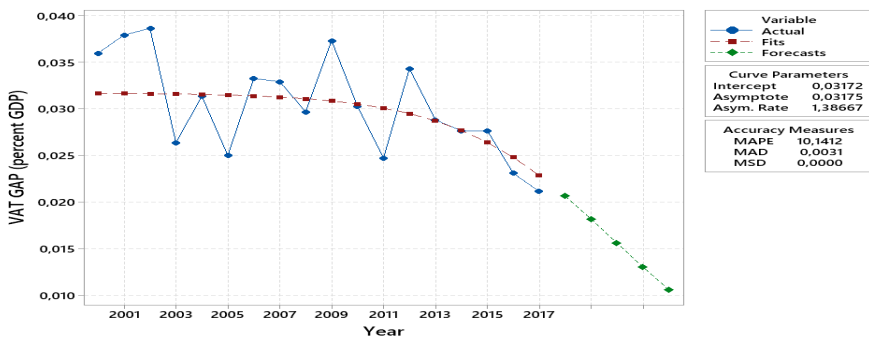


Figure 10. Graphical representation of deviation of individual models used for analysing time series trend

