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The impact of the COVID-19 pandemic on tax revenues in the EU

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ABSTRACT

The COVID-19 pandemic has led to an economic crisis with far-reaching effects throughout the entire world. In the EU, governments face the need for policies that will counter the negative economic effects. To do this, they require reliable tax revenue predictions to help plan and finance policies that will set the European economies on the road to recovery. The current study aims to offer up-to-date accurate forecasts of tax revenues for the 27 EU member states for the period 2020-2022. A time trend model regression model adjusted with the unemployment rate is estimated for each member state using data for the period 1995-2019. Based on this regression model, forecasts for tax revenues are made. The results show a decline in tax revenues in 2020 and 2021 followed by a slight recovery in 2022 for most EU member states. The study also offers fiscal policy recommendations for the EU aimed at improving and stabilizing tax revenue collection in the future.

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1. Introduction

The pandemic has taken its toll on the economies of all the EU member states. Unemployment that was initially seen as temporary due to social distancing rules or travel restrictions, became permanent as the health crisis stretched on, and an increasing number of businesses either went bankrupt or needed to lay off employees. Negative economic growth is expected to be around −12% in Spain and between −9% and −10% in Italy, Portugal, Greece, and Croatia as countries mostly reliant on services in general and tourism, in particular, have suffered the most (Fernandes, 2020). Government spending has increased significantly due to government efforts to provide healthcare services and safety equipment, to finance research, to pay unemployment benefits and give financial support to severely affected sectors such as tourism and air transport.

In anticipation of large budget deficits for 2020, the European Commission approved a suspension of the EU's limit on the budget deficit which is set at 3% of

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the GDP. This was accomplished by activating the general escape clause of the Stability and Growth Pact for the first time through COM(2020) 123 issued on the 20th of March 2020. According to the European Commission's forecasts (Autumn 2020), none of the member states are expected to have budget deficits below 3% of the GDP in 2020, with the lowest values estimated for Bulgaria (3%) and Sweden (3.9%). Five member states are expected to have budget deficits that exceed 10% of the GDP: Spain, Belgium, Italy, France, and Romania. Government debt levels were already high in 2019 for many European countries, particularly those in the Euro area. Consequently, governments will rely more heavily on tax revenues to finance government spending which makes accurate forecasts of these revenues highly important for future policy decisions and economic recovery.

The previous economic crisis, the financial crisis of 2008-2010, has had a significant impact on tax revenue collection in the EU. According to Eurostat, total average revenue from taxes and social contributions decreased by 5.6% in 2009 compared to 2008 and it was only in 2011 that the average tax revenue in the EU reached levels that exceed those from the year previous to the beginning of the financial crisis. In conclusion, two-three years were necessary for the EU member states to recover from the effects of the financial crisis. Since the current health crisis is still ongoing, it could take even longer for the EU economies to recover this time. Moreover, the current economic crisis is significantly different from the 2008-2010 financial crisis. One major difference that needs to be underlined is the impact on the level of unemployment. The financial crisis of 2008 led to an economic recession which was accompanied by increasing levels of unemployment, as expected. But the average unemployment rate for EU-27, according to the OECD, only increased by 2% in 2009 compared to 2008. The impact of the current crisis on the unemployment rate is expected to be much higher. This is one of the main reasons why the unemployment rate predictions are included in the current research.

The current study aims to provide estimations of tax revenues for each EU member state for the period 2020-2022. The expectation is that tax revenues will suffer in 2020 as many countries approved tax relief measures and postponement of tax payment deadlines in an effort to counteract the effect of the pandemic on businesses and self-employed taxpayers. Consequently, the current study will focus on two main objectives: (1) estimating how big of an impact the pandemic will have on tax revenues; and (2) estimating how long it will take each member state to recover.

2. Literature review

The current health crisis has negatively impacted all the sectors of the economies of the world. Public deficits and government debt levels are expected to reach levels similar to those seen during the Great Depression (Wheelock, 2020). Firms in all non-financial sectors have already experienced major loss of valuation (up to 60%) and increases in the cost of equity as their sales have dropped (Rizvi et al., 2020b). Diminishing levels of revenues and delayed cash flows have given rise to mounting concerns regarding corporate solvency and bankruptcy (Mirza et al., 2020b). Human capital efficiency has been proven to be the determining factor for persistence in

terms of performance during the outbreak (Mirza et al., 2020a; Yarovaya et al., 2021). Investment strategies have been affected as well with investors switching from countries with a higher number of COVID-19 cases to those with lower epidemic levels (Rizvi et al., 2020a).

The unemployment rate can be considered a barometer for the social impact of the pandemic, given the rapid spikes in the number of unemployed people. The expectations are that the unemployment rate will reach levels which will be comparable to those from the Great Depression (Petrosky-Nadeau & Valletta, 2020). In addition, forecasts regarding how much time it will take the unemployed to find new jobs are also pessimistic (Chodorow-Reich & Coglianese, 2021; Sahin et al., 2020).

The current study aims to add to the existing literature on the economic impact of the COVID-19 pandemic by focusing on its likely effects on tax revenue collection. Tax revenues are predicted to drop severely (Rephann, 2020) and the current research will attempt to use forecasting techniques to assess the likely impact of the pandemic on tax revenue collection in the EU. Tax revenue estimating methods come in a variety of shapes and sizes: simple trend models, time series forecasting, simulations, regression models, expert judgement forecasting, consensus forecasting. Many times, central and local governments will use a combination of several methods when estimating tax revenues or they will use different methods for different categories of taxes.

Willoughby and Guo (2008) look at the accuracy of tax revenue forecasts at state level in the US. Their results show that using a combination of quantitative and qualitative methods leads to greater accuracy of estimations of tax revenues. However, they also conclude that "highly complex analytical methods of forecasting do not necessarily result in greater accuracy". Penner (2008) underlines the role political agendas play in warping tax revenue predictions as policymakers struggle with the uncertainty of the budgetary outcome of any decisions they might agree on. Buettner and Kauder (2010) show evidence of possible government manipulation having a significant positive effect on the accuracy of tax revenue forecasts using data from selected OECD countries. Additional research on political influence on tax revenue forecasts shows that, though consensus forecasting can help reduce the influence of the political factor, there is little evidence of an improvement in the overall accuracy of tax revenue predictions when consensus forecasting is used (Boyd & Dadayan, 2014; Voorhees, 2004).

Estimating tax revenues in the European Union is not only important for each individual government, but it is also of interest to the European Commission. Breuer (2015) studied projections for tax revenues in Germany with the conclusion that revenues for medium term were overestimated. Botric and Vizek (2012) analysed the accuracy of official government estimations of tax revenue in Croatia before it joined the EU. Their results showed that linear time trend or random walk models provided more accurate forecasts of tax revenues than the official ones. Hannon et al. (2016) analysed the sources of errors in tax revenue forecasts in Ireland and concluded that a review of the procedures and assumptions used would improve the forecasts rather than focusing on improving estimates of revenues from previous years or other economic factors. A similar study conducted by Afonso and Carvalho (2014) for EU-15

countries shows that errors in estimating the GDP, election years and minority governments lead to overestimation of tax revenues while inflation rate estimation errors lead to underestimation of tax revenues.

The difficulties in forecasting tax revenues come from a variety of sources, from problems with data and understanding the tax structure to the impact of recessions and the limits of econometric tools (Mikesell, 2018). However, tax revenue forecasting is central to budget planning and fiscal policy reforms which leads researchers on a constant search for better predictions.

3. Method and materials

3.1. Research method

Despite the existence of significant research literature published on fiscal and budgetary forecasting, there is a clear lack of consensus on which method leads to the best results. Many researchers argue in favour of using simple econometric methods instead of the more complex models or automated techniques (Bretschneider et al., 1989; Grizzle & Klay, 1994; Lawrence et al.,1998; Leal et al., 2008) while pointing out that more complicated techniques are not necessarily more accurate, but have cost and acceptance disadvantages (Shkurti, 1990; Sun, 2005; Zhao, 2020). After analysing more than fifty prediction models for government tax revenues, Boyd et al. (2011) conclude that the more sophisticated models do not necessarily yield more accurate estimations.

Additionally, the current economic crisis caused by the COVID-19 pandemic makes the use of more complex prediction models such as autoregressive regressions even less likely to provide accurate results. These models use past behaviour to predict future behaviour, but the type of economic crisis the world is currently facing is unlike anything recorded before, whether we consider economic recessions due to regular downturns in the economic cycle or the effects of natural disasters which are of relatively short duration compared to the current ongoing medical crisis. All in all, a simple time trend regression model is much more appropriate in the current circumstances. Consequently, this will be the prediction method used in the current study.

To improve accuracy and account for the contraction in economic activity experienced by each member state of the EU, the unemployment rate will also be included as an independent variable in the regression model. Going back to the basics of macroeconomics, economic recessions are accompanied by high rates of unemployment while economic boom periods are associated with low levels of unemployment. Fiedler et al. (2019) propose assessing a state's periods of "economic weakness" by using a threshold for its unemployment rate. Bartik (2020) uses the same idea to establish a process of allocating federal pandemic aid to the areas that need it the most. Zhao (2020) and Worthington (2020) estimate state tax revenues using models which include the unemployment rate as an approximation of changes in economic activity. This type of approach is appropriate for the purpose of the current research study as one of the first and most significant economic consequences of the pandemic is an increase in unemployment levels.

To sum up, the research prediction models used in the current study are based on two assumptions: (1) the tax revenue of each member state of the EU would follow a long-term simple time trend if there were no economic cycles and (2) the effect of the state of economic activity (due to business cycles), which is approximated by the unemployment rate, makes the tax revenue deviate from the previously established trend.

The linear time trend model used is:

$$TAX\_REV_{it} = \alpha + \beta * t + \gamma * UNEMP\_R_{it}, \quad (1)$$

where TAX_REV_{it} is the total tax revenue per capita in EU member state i in year t, t is standardized and it is equal to 1 for the first year, i represents each of the 27 member states of the EU ($i = 1, 2, 3 \ldots 27$), and $UNEMP\_R_{it}$ represents the unemployment rate in EU member state i in year t. The quadratic time trend model used is:

$$TAX\_REV_{it} = \alpha + \beta_1 * t + \beta_2 * t^2 + \gamma * UNEMP\_R_{it}, \quad (2)$$

Both the simple time trend model and the quadratic time trend model are estimated for each member state of the EU and the best one is chosen to be used for predictions of the tax revenue.

3.2. Database

The data used in the regression models was collected from the Eurostat database for a period of 25 years between 1995 and 2019. The first variable used was annual total tax revenue from taxes and social contributions after deduction of amounts assessed but unlikely to be collected, in millions of euros (dataset code GOV_10A_TAXAG). The first adjustment for this data set was to exclude property taxes. According to Taxation Trends 2019, property taxes in the European Union include recurrent taxes on immovable property; recurrent taxes on net wealth; estate, inheritance, and gift taxes; and other recurrent taxes on property. As these are considered to be fairly stable (Oates & Fischel, 2016; Presbitero et al., 2014; Zhao, 2020), they are unlikely to be affected by the pandemic and, therefore, they should be deducted from the total tax revenue which will be included in the regression models.

Secondly, the resulting tax revenue was converted into 2019 prices using the Harmonised Indices of Consumer Prices (HICP) also provided by Eurostat (dataset code PRC_HICP_AIND). This adjustment is used to account for the effects of inflation in the different member states and make the predictions based on the regression models more accurate. Finally, per capita tax revenue was calculated using the population data for each member state provided by Eurostat (dataset code DEMO_PJANGROUP). This additional adjustment accounts for fluctuations in the population which might lead to changes in the total tax revenue due to demographic rather than economic reasons. After all adjustments, the resulting data for each member state will be included in the regression models as total tax revenue per capita (the notation used for this variable in equations (1) and (2) above is TAX_REV_{it}).

The second variable used was the annual unemployment rate in each member state calculated using the number of people who are unemployed, with ages between 15 and 74, as percentage of the active population. The data was taken from the Eurostat database (dataset code UNE_RT_A). This dataset was included in the regression models as the unemployment rate (the notation used for this variable in equations (1) and (2) above is UNEMP_R_{it}). There are a few member states for which data regarding the unemployment rate was not available for each of the 25 years included in the research period. For example, Bulgaria and Croatia have provided information regarding their unemployment rate beginning with the year 2000. This is the reason why the number of observations is not 25 for some countries when the regression models' estimation results are presented (please see Table 1).

3.3. Choosing the appropriate forecasting model

Two regression models were estimated for each member state: a quadratic time trend model (Model 1) and a linear time trend model (Model 2). The results are presented in Table 1. Out of the two, the most appropriate forecasting model was chosen based on two criteria: (1) the quadratic time trend model (Model 1) was chosen if the coefficient estimated for t^2 is statistically significant and (2) the quadratic time trend model (Model 1) was chosen if it explains the changes of the dependent variable better (higher value of R^2). In Table 1 the selected forecasting model for each country is presented in bold font.

After applying the two selection criteria, the quadratic time trend model (Model 1) was selected for 14 member states (Austria, Bulgaria, Croatia, Cyprus, Czechia, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Portugal, Romania, and Spain) and the linear time trend model (Model 2) was selected for the other 13 member states.

3.4. Forecast evaluation

The forecasting accuracy of the chosen regression models can be evaluated using a series of indicators as shown in Table 2. The first indicator is the Mean Absolute Error (MAE). It is calculated using the formula below and it shows the size of the error that can be expected from the prediction on average. To have accurate predictions, the value of this indicator should be as small as possible.

$$MAE = \frac{1}{n}\sum|e_t|,$$

where n is the total number of observations and e_t is the error for each time period t. The error is calculated as the difference between the actual value (of total tax revenue per capita) and the value predicted by the model. MAE is calculated based on the absolute value of the errors.

The second indicator is the Root Mean Squared Error (RMSE). This is an indicator which puts the focus on large, but infrequent errors rather than focusing on the mean. The lower the value of this indicator, the more accurate the predictions are. In addition, RMSE can be compared to MAE. The larger the difference between the two indicators, the more inconsistent the error size which leads to less accurate predictions.

Table 1. Estimation of forecasting regression models per member state.

Country		t	t^2	Unempl. rate	Const.	R^2	No. obs.
AUSTRIA	**Model 1**	0.238658***	−0.002943**	−34.06985***	16.52791***	0.95	25
		(8.029188)	(-2.745066)	(-3.795044)	(43.11475)		
	Model 2	0.160476***	–	−31.10935***	16.75246***	0.94	25
		(16.56640)	–	(-3.064881)	(39.27589)		
BELGIUM	Model 1	0.129191**	−0.000343	−26.48111*	17.37731***	0.85	25
		(2.617088)	(-0.204142)	(-2.363110)	(17.25462)		
	Model 2	0.119530***	–	−26.06527**	17.38983***	0.85	25
		(8.677897)	–	(-2.412093)	(17.64054)		
BULGARIA	**Model 1**	−0.087425***	0.004235***	−4.723046***	2.328108***	0.97	20
		(-4.524545)	(7.292866)	(-8.332940)	(12.35350)		
	Model 2	0.050389***	–	−3.486480***	1.220264***	0.9	20
		(6.195673)	–	(-3.195489)	(5.423206)		
CROATIA	**Model 1**	0.134837***	−0.002837***	−11.39785***	4.183091***	0.96	20
		(4.819088)	(-3.181746)	(-12.72695)	(17.67328)		
	Model 2	0.047126***	–	−11.24885***	4.747482***	0.93	20
		(7.937877)	–	(-10.14642)	(24.43901)		
CYPRUS	**Model 1**	0.523586***	−0.010342***	−23.34557***	3.882738***	0.92	23
		(9.009098)	(-5.089889)	(-8.664912)	(10.60037)		
	Model 2	0.239891***	–	−24.73588***	5.476584***	0.82	23
		(9.724479)	–	(-6.158693)	(19.23410)		
CZECHIA	**Model 1**	0.455678***	−0.011681***	−32.46936***	3.583709***	0.96	22
		(8.300121)	(-5.563220)	(-5.190337)	(6.614098)		
	Model 2	0.164318***	–	−13.50773	3.697151***	0.89	22
		(6.217077)	–	(-1.604295)	(4.254180)		
DENMARK	Model 1	0.238312***	−0.001915	−47.18257***	21.66811***	0.87	25
		(31.09174)	(-0.744972)	(-4.829893)	(31.09174)		
	Model 2	0.188846***	–	−48.47313***	21.96213***	0.86	25
		(11.58238)	–	(-5.093695)	(38.62923)		
ESTONIA	Model 1	0.234955***	−0.002034	−9.391643***	2.532335***	0.97	23
		(5.681830)	(-1.382345)	(-4.678939)	(7.575911)		
	Model 2	0.179484***	–	−8.834285***	2.769244***	0.96	23
		(17.57833)	–	(-4.393896)	(9.437021)		
FINLAND	Model 1	−0.036243	0.004139	−47.32754***	20.36091***	0.91	24
		(-0.394057)	(1.428974)	(-4.923294)	(14.50179)		
	Model 2	0.092980***	–	−37.31193***	18.67728***	0.90	24
		(5.409239)	–	(-5.535645)	(23.87348)		
FRANCE	Model 1	0.116450**	0.000830	−14.62113**	14.16540***	0.93	25
		(2.256008)	(0.459103)	(-2.096297)	(15.95524)		
	Model 2	0.139730***	–	−12.49712**	13.84790***	0.93	25
		(14.74945)	–	(-2.438449)	(25.33188)		
GERMANY	**Model 1**	−0.187477***	0.011494***	−11.59736*	15.27784***	0.94	24
		(-4.716301)	(5.917220)	(-1.785482)	(24.67133)		
	Model 2	0.023839	–	−36.69096***	16.82014***	0.83	24
		(0.843661)	–	(-4.607609)	(18.50024)		
GREECE	**Model 1**	0.303924***	−0.007956***	−9.429890***	5.877158***	0.93	25
		(13.36465)	(-8.933014)	(-9.929718)	(37.36582)		
	Model 2	0.113746***	–	−12.01283***	6.969548***	0.68	25
		(6.647138)	–	(-6.204181)	(32.91586)		
HUNGARY	**Model 1**	0.192985***	−0.006133**	−14.43049***	4.582528***	0.53	23
		(3.105626)	(-2.753741)	(-3.631183)	(12.29450)		
	Model 2	0.024836*	–	−8.826750**	5.053608***	0.34	23
		(1.868934)	–	(-2.242914)	(13.23683)		
IRELAND	**Model 1**	0.447941***	−0.008025***	−38.94794***	11.49725***	0.94	25
		(6.693117)	(-3.210871)	(-12.72205)	(25.93709)		
	Model 2	0.239511***	–	−39.20366***	12.45493***	0.91	25
		(12.32801)	–	(-10.73787)	(31.83783)		
ITALY	**Model 1**	0.168869**	−0.005331**	−16.56934**	12.65845***	0.69	25
		(2.612533)	(-2.170573)	(-2.798486)	(15.35420)		
	Model 2	0.030758**	–	−25.48977***	14.15673***	0.62	25
		(2.500540)	–	(-5.531964)	(29.04934)		

(*continued*)

Table 1. Continued.

Country		t	t^2	Unempl. rate	Const.	R^2	No. obs.
LATVIA	Model 1	0.136899***	−0.000648	−9.785032***	2.483475***	0.97	23
		(5.347209)	(-0.716276)	(-9.089180)	(11.93945)		
	Model 2	0.119023***	–	−9.659852***	2.563633***	0.97	23
		(21.10427)	–	(-9.206289)	(14.80261)		
LITHUANIA	Model 1	0.135729***	0.0000077	−8.885324***	2.172829***	0.97	23
		(4.985429)	(0.008164)	(-8.225841)	(9.422810)		
	Model 2	0.135945***	–	−8.885719***	2.171711***	0.97	23
		(21.68224)	–	(-8.448361)	(12.01417)		
LUXEMBOURG	**Model 1**	1.238289***	−0.016627***	−101.6441***	25.69478***	0.96	25
		(9.629691)	(-4.171083)	(-3.245554)	(31.19702)		
	Model 2	0.759195***	–	−74.14693*	27.04841***	0.94	25
		(9.939620)	–	(-1.833152)	(27.04609)		
MALTA	Model 1	0.250054**	−0.003497	−44.05969**	6.042537***	0.97	23
		(3.345443)	(-1.039390)	(-2.392176)	(6.034752)		
	Model 2	0.173434***	–	−26.61137***	5.212979***	0.96	23
		(14.00480)	–	(-3.504634)	(8.604397)		
NETHERLANDS	Model 1	0.066815	0.003946*	−31.07434***	15.05766***	0.87	25
		(1.143566)	(1.796113)	(-4.290932)	(30.47248)		
	Model 2	0.168666***	–	−28.70491***	14.48996***	0.86	25
		(11.42093)	–	(-3.841529)	(36.35343)		
POLAND	Model 1	0.033553	0.001306	−6.164255***	3.186303***	0.91	22
		(0.738578)	(0.799272)	(-3.287177)	(7.765026)		
	Model 2	0.068059***	–	−6.693948***	3.072888***	0.90	22
		(4.859686)	–	(-3.852673)	(8.057964)		
PORTUGAL	**Model 1**	0.204377***	−0.003434***	−11.61802***	5.162111***	0.96	25
		(11.51773)	(-5.446790)	(-11.02546)	(51.91238)		
	Model 2	0.111477***	–	−10.32864***	5.499950***	0.91	25
		(15.00528)	–	(-6.628256)	(46.62860)		
ROMANIA	**Model 1**	0.110069***	−0.004433**	−31.33915***	3.688538***	0.86	20
		(3.059384)	(-2.252997)	(-4.643342)	(7.387187)		
	Model 2	0.033770**	–	−23.40347***	3.354395***	0.82	20
		(2.482323)	–	(-3.628985)	(6.280826)		
SLOVAKIA	Model 1	0.047493*	0.002763**	−9.404490***	3.750080***	0.98	23
		(1.828090)	(2.763146)	(-6.418558)	(14.94300)		
	Model 2	0.116511***	–	−11.48900***	3.725332***	0.97	23
		(14.13003)	–	(-7.926079)	(12.87147)		
SLOVENIA	Model 1	−0.028969	0.002713*	−21.14004***	8.684311***	0.79	23
		(-0.771048)	(2.070876)	(-6.170576)	(27.94324)		
	Model 2	0.047147***	–	−21.71370***	8.309379***	0.75	23
		(5.611572)	–	(-5.892806)	(30.48431)		
SPAIN	**Model 1**	0.162321***	−0.003193**	−14.89317***	9.223237***	0.93	25
		(4.394590)	(-2.270438)	(-12.23049)	(29.20586)		
	Model 2	0.080684***	–	−15.97307***	9.759660***	0.91	25
		(8.755279)	–	(-13.06856)	(42.71594)		
SWEDEN	Model 1	0.245167*	−0.003399	−31.60219*	19.32874***	0.62	25
		(1.717888)	(-0.648943)	(-1.764353)	(10.72388)		
	Model 2	0.154921***	–	−35.95420**	20.07062***	0.61	25
		(4.896943)	–	(-2.193844)	(14.59690)		

Source: Author's calculations using Eviews.
Note: t-statistic values in ().
***Indicates the statistical significance at 1% level.
**Indicates the statistical significance at 5% level.
*Indicates the statistical significance at 10% level.

$$RMSE = \sqrt{\frac{1}{n}\sum e_t^2}$$

The next indicator calculated is the Mean Absolute Percentage Error (MAPE). As can be seen from the formula below, MAPE is basically the sum of each error (in

Table 2. Forecasting evaluation.

Country	MAE	RMSE	MAPE	Theil Inequality Coef.	Bias Proportion	Variance Proportion
AUSTRIA	0.172031	0.226267	0.99%	0.006508	0.000000	0.011278
BELGIUM	0.387333	0.471646	2.31%	0.013801	0.000000	0.040063
BULGARIA	0.046271	0.065670	3.24%	0.019425	0.000000	0.005827
CROATIA	0.074623	0.105525	1.85%	0.012994	0.000000	0.010589
CYPRUS	0.265604	0.345758	3.69%	0.024369	0.000000	0.019090
CZECHIA	0.227270	0.268091	4.47%	0.024816	0.000000	0.010180
DENMARK	0.431630	0.545084	1.97%	0.012574	0.000000	0.035178
ESTONIA	0.196178	0.258630	4.41%	0.027672	0.000000	0.008764
FINLAND	0.306951	0.397841	1.82%	0.011943	0.000000	0.026275
FRANCE	0.224075	0.289245	1.57%	0.009947	0.000000	0.017019
GERMANY	0.225670	0.281266	1.59%	0.009715	0.000000	0.015559
GREECE	0.140721	0.180378	2.11%	0.013412	0.000000	0.016908
HUNGARY	0.246439	0.327246	5.21%	0.034286	0.000000	0.156888
IRELAND	0.419458	0.531230	3.37%	0.021338	0.000000	0.015033
ITALY	0.269049	0.375918	2.33%	0.015591	0.000000	0.091865
LATVIA	0.113666	0.154651	3.83%	0.023805	0.000000	0.006220
LITHUANIA	0.142927	0.162309	4.98%	0.024699	0.000000	0.005230
LUXEMBOURG	0.717075	0.828589	2.14%	0.012183	0.000000	0.007823
MALTA	0.202920	0.243461	3.79%	0.019702	0.000000	0.007670
NETHERLANDS	0.435719	0.493291	2.88%	0.016084	0.000000	0.037795
POLAND	0.205948	0.236897	6.31%	0.034941	0.000000	0.024824
PORTUGAL	0.100220	0.130609	1.64%	0.010709	0.000000	0.009112
ROMANIA	0.133816	0.173701	6.96%	0.039416	0.000000	0.036576
SLOVAKIA	0.134869	0.173625	3.86%	0.021783	0.000000	0.005924
SLOVENIA	0.189999	0.247245	2.60%	0.016524	0.000000	0.073052
SPAIN	0.206868	0.275260	2.47%	0.016795	0.000000	0.019374
SWEDEN	0.867306	1.042857	4.57%	0.026738	0.000000	0.120304

Source: Author's calculations using Eviews.

absolute terms) divided by the actual value. The lower the value of the indicator, the more accurate the predictions.

$$MAPE = \frac{1}{n}\sum \frac{|e_t|}{a_t},$$

where a_t is the actual value (for total tax revenue per capita) for time period t.

The fourth indicator is the Theil inequality coefficient. It always has values between zero and one. Since zero indicates a 'perfect fit', the closer the value of the indicator to zero, the better the prediction accuracy of the model will be.

For additional evaluation criteria, the components of the mean squared forecast error are considered: the bias proportion, the variance proportion, and the covariance proportion. The bias proportion shows how far the mean of the forecast will be from the mean of the actual series. The variation proportion shows how far the variation of the forecast will be from that of the actual series. The smaller the values for the bias proportion and the variance proportion, the more accurate the forecast. Small values for these two indicators reveal that the largest part of the bias comes from the covariance proportion which shows unsystematic forecasting errors.

Table 2 shows the values for the forecasting evaluation indicators for each prediction model selected. Both MAE and RMSE have values that are close to zero (below 1 for most prediction models). The difference between the two indicators for each country is small which shows that the forecast will most likely not contain large infrequent errors. In addition, the Theil inequality coefficient is close to zero (smaller

than 0.04) for all models chosen which supports the decision that using these regression models will lead to fairly accurate predictions.

The values calculated for MAPE show that, for most of the countries, the predictions will be less than 5% off the actual values. This again points to good forecasting accuracy. The only exceptions are Poland (6.31%) and Romania (6.96%), but even in these cases the predicted values should not be more than 7% off the actual values. So, it can be said that the MAPE indicator confirms the high accuracy of the forecasting models chosen. The last two indicators included in Table 2 (bias proportion and variance proportion) have values close to zero. This further strengthens the conclusion regarding the expected accuracy of the forecasted values for tax revenue per capita using the chosen time trend regression models for each of the member states of the European Union.

4. Research results

After attesting the prediction accuracy of the chosen regression models for each member state of the European Union, these were used to estimate tax revenues for the next three years (2020, 2021, 2022). The research results are presented in Tables 3 and 4. The predicted values for the tax revenue are considered under two different scenarios: the first one uses the predicted unemployment rates for each country provided by the European Commission in its Economic Forecast – Autumn 2020 (European Commission, Economic and Financial Affairs, 2020); while the second scenario uses predicted unemployment rates for the EU member states made available by the OECD (OECD, 2020). The predictions made by the European Commission are confirmed by Statista (Clark, 2020; Plecher, 2020), while those made by the OECD are fairly close to unemployment predictions made by the International Labour Organisation (International Labour Organization, 2020). One drawback that must be mentioned is the fact that the OECD does not provide unemployment predictions for all the EU member states, there is no data available for Croatia, Cyprus, and Malta.

The tax revenue prediction results using the European Commission unemployment predictions (Autumn 2020) are presented in Table 3. Most of the EU member states are expected to see decreases in tax revenues in 2020 compared to 2019. There are four exceptions (Slovakia, Germany, France and Bulgaria), but even in these cases the expected increase in tax revenues is around 1%, significantly less than in previous years and probably not enough to decrease the budget deficit. The most significant decreases in tax revenue (around 10%) are expected in Hungary and Czechia, while tax revenues in Poland and Lithuania are expected to drop by almost 7%. The most concerning prediction is that for Romania where tax revenues in 2020 are expected to decrease by 25%. Romania's government has decided to postpone collecting corporate income taxes twice in 2020 in an effort to help businesses which were affected by lockdown measures: initially the March deadline was postponed to September and then it was moved further back.

According to the results presented in Table 3, 15 member states are expected to have more tax revenues in 2021 than 2020. However, many of these (Austria, Croatia, Cyprus, Denmark, Estonia, Finland, Lithuania, Malta, Portugal, Slovenia, and Sweden) are still not expected to reach the 2019 tax levels in 2021. In fact, only

Table 3. European Commission scenario results.

	2020			2021			2022		
	Unempl. rate	% change in tax revenue from 2019	% change in tax revenue from previous year	Unempl. rate	% change in tax revenue from 2019	% change in tax revenue from previous year	Unempl. rate	% change in tax revenue from 2019	% change in tax revenue from previous year
AUSTRIA	5.5	−2.05	−2.05	5.1	−0.91	1.16	4.9	−0.16	0.76
BELGIUM	5.9	−0.06	−0.06	7	−0.92	−0.87	6.2	0.78	1.71
BULGARIA	5.8	0.84	0.84	5.6	6.43	5.54	5	13.06	6.23
CROATIA	7.7	−3.26	−3.26	7.5	−3.12	0.15	6.9	−2.19	0.96
CYPRUS	8.2	−4.40	−4.40	7.8	−3.63	0.80	7.2	−2.57	1.10
CZECHIA	2.7	−11.97	−11.97	3.3	−16.71	−5.38	3.2	−18.75	−2.45
DENMARK	6.1	−2.57	−2.57	5.8	−1.20	1.40	5.5	0.16	1.38
ESTONIA	7.5	−3.64	−3.64	7.8	−1.47	2.26	6.7	2.47	3.99
FINLAND	7.9	−1.63	−1.63	7.7	−0.73	0.92	7.4	0.38	1.12
FRANCE	8.5	1.32	1.32	10.7	0.48	−0.82	10	1.88	1.40
GERMANY	4	0.90	0.90	4	3.23	2.30	3.8	5.82	2.51
GREECE	18	−2.45	−2.45	17.5	−3.48	−1.05	16.7	−4.33	−0.88
HUNGARY	4.4	−10.65	−10.65	4.4	−13.10	−2.74	3.9	−14.44	−1.54
IRELAND	5.3	−2.92	−2.92	8.9	−11.48	−8.81	8.7	−10.96	0.59
ITALY	9.9	−3.80	−3.80	11.6	−7.02	−3.35	11.1	−7.36	−0.36
LATVIA	8.3	−0.26	−0.26	8	2.78	3.05	7.5	6.22	3.34
LITHUANIA	8.9	−6.89	−6.89	8	−2.80	4.39	6.9	1.63	4.55
LUXEMBOURG	6.6	−4.55	−4.55	7.1	−4.91	−0.38	7.1	−4.14	0.81
MALTA	5.1	−3.80	−3.80	4.7	−0.58	3.35	4.1	3.25	3.85
NETHERLANDS	4.4	−3.64	−3.64	6.4	−5.86	−2.30	6.1	−4.47	1.48
POLAND	4	−7.47	−7.47	5.3	−7.85	−0.41	4.1	−4.85	3.26
PORTUGAL	8	−3.41	−3.41	7.7	−2.65	0.79	6.6	−0.73	1.97
ROMANIA	5.9	−25.54	−25.54	6.2	−30.99	−7.31	5.1	−22.31	12.57
SLOVAKIA	6.9	1.02	1.02	7.8	1.24	0.22	7.1	4.57	3.30
SLOVENIA	5	−2.42	−2.42	4.8	−1.38	1.07	4.4	0.17	1.57
SPAIN	16.7	−3.38	−3.38	17.9	−5.41	−2.11	17.3	−4.58	0.88
SWEDEN	8.8	−2.62	−2.62	9.2	−2.57	0.05	8.1	−0.01	2.63

Source: Author's calculations.
Note: Unemployment rate is based on the EC Autumn 2020 predictions.

Table 4. OECD scenario results.

	2020			2021			2022		
	Unempl. rate	% change in tax revenue from 2019	% change in tax revenue from previous year	Unempl. rate	% change in tax revenue from 2019	% change in tax revenue from previous year	Unempl. rate	% change in tax revenue from 2019	% change in tax revenue from previous year
AUSTRIA	5.6	−2.22	−2.22	5.6	−1.79	0.44	5.1	−0.51	1.31
BELGIUM	5.7	0.21	0.21	7.9	−2.13	−2.34	6.8	−0.03	2.15
BULGARIA	6.4	−0.24	−0.24	6.1	5.53	5.78	5.1	12.88	6.97
CZECHIA	2.6	−11.54	−11.54	3.6	−17.99	−7.30	3.6	−20.46	−3.01
DENMARK	5.7	−1.78	−1.78	6.2	−1.99	−0.22	5.7	−0.24	1.79
ESTONIA	6.8	−2.76	−2.76	7.6	−1.22	1.59	7.3	1.72	2.97
FINLAND	7.9	−1.63	−1.63	8.3	−1.94	−0.31	7.7	−0.22	1.75
FRANCE	8.4	1.39	1.39	10.5	0.64	−0.75	10.2	1.73	1.09
GERMANY	4.2	0.77	0.77	4.8	2.69	1.90	4.3	5.48	2.72
GREECE	16.9	−0.95	−0.95	17.8	−3.89	−2.98	17.2	−5.02	−1.17
HUNGARY	5	−12.26	−12.26	6.4	−18.45	−7.06	5.7	−19.25	−0.99
IRELAND	5.3	−2.92	−2.92	8	−9.31	−6.57	7.8	−8.78	0.58
ITALY	9.4	−3.13	−3.13	11	−6.21	−3.19	10.9	−7.09	−0.94
LATVIA	8.4	−0.45	−0.45	8.8	1.20	1.66	8.1	5.03	3.79
LITHUANIA	8.8	−6.72	−6.72	8.1	−2.97	4.02	7.3	0.96	4.04
LUXEMBOURG	6.4	−4.07	−4.07	7	−4.67	−0.63	6.4	−2.44	2.34
NETHERLANDS	4.1	−3.17	−3.17	6.1	−5.39	−2.29	6.3	−4.78	0.64
POLAND	3.8	−7.20	−7.20	5.5	−8.12	−1.00	4.3	−5.12	3.27
PORTUGAL	7.3	−2.33	−2.33	9.5	−5.44	−3.19	8.2	−3.22	2.35
ROMANIA	5.5	−21.43	−21.43	7	−39.22	−22.64	6.3	−34.66	7.50
SLOVAKIA	6.8	1.21	1.21	7.4	2.02	0.80	6.8	5.16	3.08
SLOVENIA	5.5	−3.68	−3.68	5.6	−3.38	0.30	5.2	−1.84	1.60
SPAIN	15.8	−1.90	−1.90	17.4	−4.60	−2.75	16.9	−3.92	0.70
SWEDEN	8.6	−2.29	−2.29	9	−2.24	0.05	8	0.15	2.45

Source: Author's calculations.

Slovakia, Latvia, Germany, and Bulgaria are expected to recover in terms of tax revenue collected by 2021. The highest decreases in tax revenues in 2021 are predicted for Czechia (more than 5% compared to 2020), Ireland (almost 9% less than in 2020) and Romania (more than 7% less tax revenue in 2021 compared to 2020).

Most EU member states are expected to recover in terms of tax revenues by 2022. The exceptions, according to the estimations presented in Table 3, will be Czechia, Greece, Hungary, and Italy. However, none of these four countries are expected to see decreases of more than 2-3% of their tax revenues in 2022 compared to 2021. The biggest increase in tax revenue is 2022 is expected in Romania, but it must be noted that the tax revenue collected is still not going to reach the 2019 level. Bulgaria is also expected to have an increase in tax revenues in 2022 (more than 6% over the tax revenue from 2021), but unlike Romania, Bulgaria is expected to exceed the tax revenues collected in 2019 by almost 13% in 2022.

The research results using the unemployment rate predictions of the OECD are presented in Table 4. These seem to confirm and strengthen the results presented previously using the unemployment rate predictions of the European Commission.

For most EU member states, the evolution of tax revenue predicted using the first scenario is confirmed by the second. Overall, the predictions based on the OECD unemployment estimations are more pessimistic than those using the EU predicted unemployment rate, with smaller percentage increases in 2021 and larger percentage decreases. Portugal is an exception: according to the results in Table 4 the decrease in tax revenues in 2021 will exceed 3% compared to 2020 whereas the results in Table 3 estimated an increase in tax revenues in 2021 of almost 1%.

In terms of predictions for 2022, the results in Table 4 seem to confirm the previous findings shown in Table 3 that most EU member states will see an increase of their tax revenues in 2022 compared with 2021. Even so, most member states will still not be able to collect as much tax revenue as in 2019. All in all, both sets of research results show (Tables 3 and 4) that even if most of the EU member states will be recovering by 2022, they will not have yet been able to achieve the same levels of economic activity as in 2019 before the health crisis started.

5. Conclusions and recommendations

The EU member states seem to have been caught off guard by the coronavirus pandemic and, according to the results of the current study, 2022 is the earliest when signs of recovery will become visible. If we consider tax revenues as a barometer for economic activity, then it can also be concluded that most EU member states will not be able to achieve the same levels of economic indicators in 2022 as in 2019 before the health crisis.

The current study aims to highlight a serious problem that the EU member states will need to address – declining tax revenues. Given the high pre-existing budget deficits and the current study's predictions regarding tax revenues, it becomes clear that governments will need to make some very difficult decisions. Therefore, three policy recommendation for the EU member states will be discussed in the final part of this study. All of these policies are aimed at either improving tax revenue collection in the long term or stabilizing fiscal revenues in the event of a future crisis.

5.1. Progressive income tax

According to the European Commission's Taxation Trends in Europe (European Commission, Taxation and Customs Union, 2021), there are six member states which have a flat tax policy for personal income. Looking at the research results presented in this study, some of these countries will have the biggest predicted reductions in tax revenue (Hungary and Czechia) or they will have the most difficulties in terms of recovery time (Romania). Consequently, the first fiscal policy recommendation is a progressive personal income tax. Each member state would still decide on individual tax brackets and deductions. On the one hand, progressive income taxation has a series of benefits such as diminishing income inequality and poverty levels (Berens & Gelepithis, 2019; Popescu et al., 2019). On the other hand, in the event of an economic crisis, it would increase tax collection and it would have a stabilization function (Garcia-Muniesa, 2019; Nerudová et al., 2021). This conclusion is strengthened by the current research findings (Tables 3 and 4) as some of the countries least likely to suffer decreases in tax revenue (France and Germany) and those that will recover the fastest have progressive personal income taxes, such as Germany and Latvia. It should also be noted that Latvia decided to switch to a progressive income tax system in three bands in 2018 which now seems to contribute to their tax revenue collection quick recovery predictions.

5.2. Common tax legislation regarding the profits of multinational companies

For many years there have been negotiations among the EU member states for fiscal convergence regarding corporate income taxation. The reasoning behind this was based on tax fairness and avoiding a "race to the bottom" (Janský, 2019; Valenduc, 2019). In the context of the current health and economic crisis, the research results of the current study show that the countries with low corporate income tax rates are the ones whose tax revenues will be most affected (Hungary, Czechia, Ireland), and they will have slow recoveries (Romania, Croatia). Consequently, the second fiscal policy recommendation is a common tax rate for the profits of large multinational companies. This policy measure will help increase and stabilize tax revenue collection, it will help decrease profit shifting and tax competition between the member states (Candau & Le Cacheux, 2017) and it will also allow national governments enough "freedom" to protect small, national businesses. At a recent G7 summit (June 2021), the participating countries agreed on a plan for a minimum corporate tax rate of at least 15% for multinational companies. Since France, Germany and Italy are part of this agreement and they are also some of the most influential members of the EU, it is expected that this type of policy will be adopted at EU level.

5.3. Digitalisation of tax systems

During the current health crisis, one of the factors contributing to a slowdown in tax revenue collection is the fact that most tax-related documents still need to be fill out on paper and filed in person. In addition, actually paying taxes is still done in person in most cases. With the restrictions necessary to diminish the effects of the COVID-

19 pandemic, taxes could no longer be filed or collected. Therefore, the third recommendation is the digitalization of tax systems in the EU. This would not only help stabilize tax revenue collection in the case of any future outbreaks, but it will have other significant advantages as well. Digitalization will help decrease tax evasion and tax avoidance by increasing the transparency of the real economic outcomes of the taxpayers (Devereux & Vella, 2017; Jacobs, 2017). Digitalization will play a part in making tax collection more efficient for both the government and the taxpayer (Jingnan et al., 2017). This a long-term solution which would require extensive funding. One source of financing which is currently available to the EU member states is the Recovery and Resilience Facility, which was approved in 2020, it includes grants and loans, and it is focused on digital transition as well as environmental sustainability.

There are a few limitations to the current study. Firstly, the accuracy of the tax revenue predictions depends on the accuracy of the unemployment rate predictions. Though four different sources were considered to ensure a high accuracy of the unemployment rate predictions, still this remains a concern. Secondly, the recommendations mainly look at taxation measures though tax revenues depend on a number of factors. The tax base, for example, will be influenced by minimum wages, availability of jobs, accuracy of income statements, all of which could influence tax revenues. Finally, the political factor has a significant influence on economic policies, and it should be noted that many EU member states will have either national election, local elections or both in 2020-2021 which could delay some of the less popular fiscal measures being implemented.

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