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ANALYZING THE ECONOMIC OUTPUT AND HUMAN LOSS PATTERNS ACROSS THE EU AND NEIGHBORING STATES DURING THE PANDEMIC

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Abstract
The article looks into Eurostat's economic output and mortality statistics covering the EU 27 member states and six neighboring countries during 2020 and the first quarter of 2021. The study identifies, across a policy mosaic, the dominant reaction to the SARS-CoV-2 pandemic along with occasional deviations from it. Nearly all deviations occurred within a long geographic zone, while the four most populous EU member states, along with six other EU member-states, did not (or were not able to) shift from the low output-high mortality situation for nearly a year. The econometric analysis reveals country-specific effects. In most counties these effects varied from one quarter to the next. However, in some countries these were consistently associated with higher output and lower mortality. Thus, there may be health and economic policy lessons to be learned from the approaches employed in such cases.

JEL Classification: C20, I15, I30
Keywords: GDP, Number of deaths, Covid-19 Pandemic, Spatial Patterns, Europe

The article has benefited from comments made to an earlier version by participants at the 17th International Conference of the ASECU, held at the University of Belgrade (September 2021). The usual disclaimer applies.

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1. Introduction

The article provides a brief overview of how 33 European states performed in terms of economic output and human losses (mortality) during the SARS-CoV-2 pandemic from the first quarter of 2020 (2020^{Q1}) to the first quarter of 2021 (2021^{Q1}); it also analyzes the patterns and engages in comparisons to help identify useful policy lessons. To this end the article uses data compiled by the EU's statistical office, Eurostat, concerning the 27 EU member states and six neighboring states: data running from one year prior to 2020^{Q1} –when the novel virus reached Europe– to 2021^{Q1} –the last quarter for which data are available at the time of writing. The six neighboring states are Iceland, Norway, Switzerland, Albania, Serbia, and a former EU member, namely, the United Kingdom of Great Britain & Northern Ireland.

Measuring welfare and comparing policy choices in terms of economic output and mortality is well grounded in relevant literature (Sen, 1998; Peltzman, 2009; Balmford *et al*. 2020). In the pages that follow output and mortality are examined together with an eye to identify variations in performance over time and across space. The two elements are proxied by the quarterly GDP figures in terms of 2015 prices, and by the total number of weekly deaths. The latter captures not only confirmed SARS-CoV-2 deaths, i.e., deaths directly attributed to the novel virus, but also deaths not correctly diagnosed or reported, as well as deaths from other causes that may be attributed to the health crisis conditions (e.g., worse access to care, etc.) vis-a-vis what would be expected prior to the pandemic (Karanikolos and McKee, 2020; Amoretti and Lalumera, 2021; Lau *et al*. 2021.). These weekly figures are converted to quarterly figures, so as to match the GDP time-series, and then both sets of quarterly figures are reformulated into indices. The indexation formula employed is the following:

$$x = \frac{\text{Real GDP figure (or the number of deaths) observed or estimated in a certain quarter}}{\text{The respespective figure observed or estimated in the same quarter in 2019}} \cdot \quad (1)$$

The procedure removes seasonality from both time-series sets and draws attention to the *excessive number of deaths* attributed to the pandemic by rendering the number of deaths comparable to the respective (pre-pandemic) figures of 2019[1].

The article is organized as follows: Section 2 reshapes the quarterly indices to quarterly scores running from zero to one, so as to identify the best performers in both higher output and lower mortality in each quarter. Section 3 shifts attention from best performers to the performance of each and every state –including likely policy shifts– by discussing the evolution and spatial patterns of the two indices from one quarter to the next. Section 3 econometrically analyses the two indices

1. Understandably, due to increased hand hygiene, the wearing of masks, and the imposition of school and business closures, as well as gathering, traveling or other restrictions (e.g., ECDC, 2020), a reduction in deaths from other causes (e.g., from other respiratory diseases, from fewer road accidents during lockdowns, etc.) is expected.

during 2020^{Q2}, 2020^{Q4} and 2021^{Q1} in terms of factors measured by Eurostat and the numbers of confirmed SARS-CoV-2 deaths listed by the World Health Organization (WHO). The latter are available only for the said quarters. Next, Section 5 discusses the findings, and Section 6 provides the conclusions.

2. Some initial calculations and comparisons

Quarterly GDP estimates are available for all countries under consideration except for the United Kingdom in 2020^{Q4}-2021^{Q}, and Albania in 2021^{Q1}. The number of deaths is available in all other cases, but $2019^{Q1\text{-}Q3}$ in the Republic of Ireland, and the last two weeks of March 2021 in Iceland. As a result, the Irish death index values for $2020^{Q1\text{-}Q3}$ and 2021^{Q1} are not calculated, and Iceland's figures of weeks 12 and 13 are filled in via linear projection based on the figures of weeks 10 and 11. Therefore, (33 – 3=) 30 counties are left for which the GDP and mortality indices may be calculated for each and every quarter of the five-quarter period.

If these 30 counties are assigned quarterly scores ranging from zero to one (zero for the least desirable, one for the most desirable index value) as per the min-max scaling formulae (2) and (3) for the GDP and the overall number of deaths, respectively,

$$\hat{x}_i = \frac{x_i - \min(x)}{\max(x) - \min(x)} \quad , \tag{2}$$

$$\check{x}_i = \frac{\max(x) - x_i}{\max(x) - \min(x)} \quad , \tag{3}$$

then the situation may be summarized as shown in Table 1.

It turns out that Serbia performed better than the EU and non-EU countries considered in terms of GDP ($\hat{x}_i$) in both 2020^{Q1} and 2021^{Q1}. Likewise, Norway performed better in 2020^{Q2}, and Luxembourg in 2020^{Q3} and 2020^{Q4}. Hungary performed better than the rest in bringing down deaths ($\check{x}_i$) in 2020^{Q1}, Croatia in 2020^{Q2}, Iceland in 2020^{Q3}, and Norway in both 2020^{Q4} and 2021^{Q1}. These are all small countries in terms of population, and lie disproportionally outside the EU, which, in turn, may suggest that there is something to be said about (a) managing small countries and (b) countries that may react independently (are not bound to check with or coordinate with others as a *block*), at least for brief periods of time.

Next, we look at the combined scores by calculating the mathematical product of the two:

$$\hat{x}_i^{w} \times \check{x}_i^{(1-w)} \tag{4}$$

with *w* featuring the weight assigned to achieving a higher GDP, and *1-w* featuring the weight assigned to achieving fewer deaths. We note (see Appendix) that: (a) Hungary and Serbia may top the county-list in 2020^{Q1} if, respectively, *w* takes values up to 0.5 or

from 0.6 on; (b) Bulgaria and Norway may top the county-list in 2020^{Q2} if, respectively, *w* is about 0.1 or runs from 0.2 on; (c) Iceland, Norway and Luxembourg may top the county-list in 2020^{Q3} if, respectively, *w* runs up to 0.1 or from 0.2 to 0.5 or from 0.6 on; (d) Norway and Luxembourg may top the county-list in 2020^{Q4} if, respectively, *w* runs up to 0.6 or from 0.7 on; (e) Norway, Luxembourg and Serbia may top the county-list in 2021^{Q1} if, respectively, *w* runs up to 0.2 or is about 0.3 or runs from 0.4 on[2].

Table 1. Performance scores on the 0-1 scale of 26 EU and four neighboring states during the pandemic

	Real GDP (score) based on the index obtained vis-à-vis 2019					Total number of deaths (score) based on the index obtained vis-à-vis 2019				
	2020^{Q1}	2020^{Q2}	2020^{Q3}	2020^{Q4}	2021^{Q1}	2020^{Q1}	2020^{Q2}	2020^{Q3}	2020^{Q4}	2021^{Q1}
AT	0.24	0.48	0.32	0.32	0.00	0.45	0.82	0.66	0.51	0.83
BE	0.36	0.43	0.37	0.37	0.40	0.49	0.05	0.63	0.51	0.95
BG	0.70	0.74	0.40	0.40	0.63	0.91	0.98	0.53	0.00	0.63
CH	0.52	0.79	0.69	0.69	0.51	0.57	0.75	0.88	0.33	0.88
CY	0.62	0.52	0.42	0.42	0.51	0.42	0.72	0.83	0.83	0.93
CZ	0.40	0.61	0.39	0.39	0.31	0.57	0.89	0.61	0.16	0.11
DE	0.37	0.58	0.62	0.62	0.22	0.58	0.80	0.73	0.77	0.81
DK	0.56	0.79	0.72	0.72	0.48	0.68	0.85	0.76	0.93	0.91
EE	0.44	0.82	0.73	0.73	0.82	0.69	0.75	0.55	0.86	0.59
ES	0.18	0.00	0.00	0.00	0.01	0.00	0.00	0.15	0.67	0.74
FI	0.45	0.85	0.78	0.78	0.39	0.68	0.66	0.68	0.95	0.91
FR	0.07	0.17	0.49	0.49	0.31	0.57	0.48	0.70	0.70	0.79
GR	0.40	0.34	0.29	0.29	0.37	0.51	0.99	0.59	0.73	0.92
HR	0.61	0.40	0.16	0.16	0.56	0.81	1.00	0.54	0.32	0.83
HU	0.72	0.46	0.51	0.51	0.55	1.00	0.89	0.80	0.32	0.66
IS	0.36	0.64	0.37	0.37	0.32	0.01	0.99	1.00	0.98	0.82
IT	0.00	0.19	0.27	0.27	0.17	0.13	0.48	0.58	0.46	0.81
LT	0.75	0.95	0.73	0.73	0.79	0.79	0.75	0.37	0.26	0.68
LU	0.64	0.77	1.00	1.00	0.95	0.81	0.68	0.62	0.69	0.82
LV	0.43	0.71	0.70	0.70	0.40	0.95	0.76	0.67	0.73	0.66
MT	0.70	0.38	0.10	0.10	0.55	0.89	0.91	0.17	0.41	0.81
NL	0.51	0.69	0.58	0.58	0.36	0.31	0.33	0.75	0.73	0.74
NO	0.66	1.00	0.79	0.79	0.55	0.52	0.92	0.87	1.00	1.00
PL	0.71	0.77	0.59	0.59	0.58	0.70	0.86	0.50	0.05	0.50
PT	0.33	0.30	0.26	0.26	0.05	0.77	0.57	0.00	0.65	0.55
RO	0.75	0.65	0.71	0.71	0.69	0.88	0.85	0.09	0.23	0.71
RS	1.00	0.86	0.75	0.75	1.00	0.71	0.94	0.39	0.44	0.80
SE	0.55	0.78	0.70	0.70	0.52	0.44	0.05	0.84	0.81	0.80
SI	0.32	0.49	0.42	0.42	0.50	0.80	0.77	0.70	0.03	0.82
SK	0.22	0.60	0.64	0.64	0.33	0.71	0.92	0.57	0.30	0.00

Key for country codes: Austria (AT), Belgium (BE), Bulgaria (BG), Croatia (HR), Cyprus (CY), Czechia (CZ), Denmark (DK), Estonia (EE), Finland (FI), France (FR), Germany (DE), Greece (GR), Hungary (HU), Iceland (IS), Italy (IT), Latvia (LV), Lithuania (LT), Luxembourg (LU), Malta (MT), Netherlands (NL), Norway (NO), Poland (PL), Portugal (PT), Romania (RO), Serbia (RS), Slovakia (SK), Slovenia (SI), Spain (ES), Sweden (SE), Switzerland (CH).

Source: Eurostat (the namq_10_GDP and demo_r_mwk_ts datasets updated, respectively, on 6 June and 17 June 2021). Author's own calculations.

2. This is not to say that the GDP or the number of deaths is more important or that they are weighted equally across Europe, or that particular social utility functions feature or are in line with the said or other weights.

To gain more insight, we turn our attention to the similarity or dissimilarity of responses observed across states, commencing from the time the pandemic reached Europe.

3. Performance patterns and shifts

The novel virus infection was first confirmed on European soil on 24 January 2020 in France, three days later in Germany, and by the end of the month in Italy, Spain, the United Kingdom and Sweden. As it spread within countries and across Europe[3], initially mild, subsequently more drastic steps were taken by authorities to slow or suppress the spread and mitigate the pandemic's impact on healthcare systems and society. These steps were met with varying success. By the end of June 2020, the number of confirmed virus-related deaths per 100 thousand population had increased substantially in Belgium, the United Kingdom, Spain, Italy, Sweden, France, the Netherlands, the Republic of Ireland, and Switzerland (Table 2, column 1); so had the total number of deaths reported in the United Kingdom, Spain, Sweden, Belgium, the Netherlands, Italy, France, Cyprus, and Iceland compared to the total number of deaths in the first two quarters of 2019 (Figures 1 and 2)[4]. At the same time, these steps also disturbed economic life.

The output and mortality statistics supplied by Eurostat suggest that in 2020^{Q1}, on average, output and overall mortality fell compared to 2019^{Q1}, and that, in general, the paths individual countries followed differed (see Figure 1). Specifically: (a) Mortality and output rose in Cyprus, Sweden, and Norway (1st quadrant). (b) Mortality rose, and output dropped along a geographic belt stretching from Belgium and the Netherlands, across the water, to the United Kingdom and Iceland; and along a belt stretching from Spain to Italy and to two of Italy's neighbors, namely, Austria and Greece (2nd quadrant). The list includes three of the six countries affected in the last week of January, i.e., earlier than the rest. (c) Both mortality and output dropped along a belt that stretched from France and Germany to Switzerland, Czechia, and Slovakia, as well as along a belt stretching from Finland to Estonia and Latvia; the same is true in Portugal, Slovenia, Albania (3rd quadrant). (d) Mortality dropped, and output rose along a belt that stretched from Hungary and Romania to Bulgaria, Serbia, and Croatia, as well as in Luxemburg, Denmark, Malta, Poland, and neighboring Lithuania (4th quadrant). So, it seems that several countries, including the quarter's *best performers*' (i.e., Serbia's and Hungary's) closest neighbors, moved in the same

3. The infection was confirmed in the last two countries considered in the article, Albania and Cyprus, on 8 March 2020.
4. The Figures supply the Cartesian coordinates (combinations) of the various countries in the output–mortality plane. The intersecting horizontal and vertical axes at the 100% mark, fix each country's 2019 quarterly output-mortality coordinates (or points) of reference, and divide the output-mortality plane into four sections (quadrants).

output and mortality direction. This may suggest more factors, presumably region-wide factors, in play besides the *best performers*' reaction or policy orientation.

Table 2. The number of confirmed SARS-CoV-2 deaths reported by national authorities per 100 thousand population

EU states	By end of 2020^{Q2} (1)	By end of 2020^{Q4} (2)	By end of 2021^{Q1} (3)
AT	7.8	63.9	99.9
BE	84.1	165.6	197.6
BG	3.2	102.5	182.1
CY	1.6	9.2	20.7
CZ	3.2	103.1	241.6
DE	10.7	35.5	90.6
DK	10.4	19.9	41.7
EE	5.2	15.4	63.9
ES	60.6	106.6	159.2
FI	5.9	9.5	14.7
FR	45.6	95.3	143.8
GR	1.8	43.7	75.1
HR	2.6	89.4	143.5
HU	6.1	93.7	206.7
IE	35.2	44.6	94.2
IT	57.5	118.5	178.0
LT	2.9	46.1	130.4
LU	17.6	75.1	117.9
LV	1.6	27.3	99.2
MT	2.0	46.7	87.2
NL	35.6	64.0	96.0
PL	3.8	71.7	137.1
PT	15.4	64.3	165.0
RO	8.5	78.5	119.5
SE	52.6	82.0	132.7
SI	5.3	121.7	207.3
SK	0.5	32.5	173.9
Other states			
AL	2.2	39.7	76.7
CH	19.4	75.2	110.7
IS	2.9	8.2	8.5
NO	4.6	7.8	12.1
RS	3.9	42.8	74.0
UK	64.2	103.7	186.4

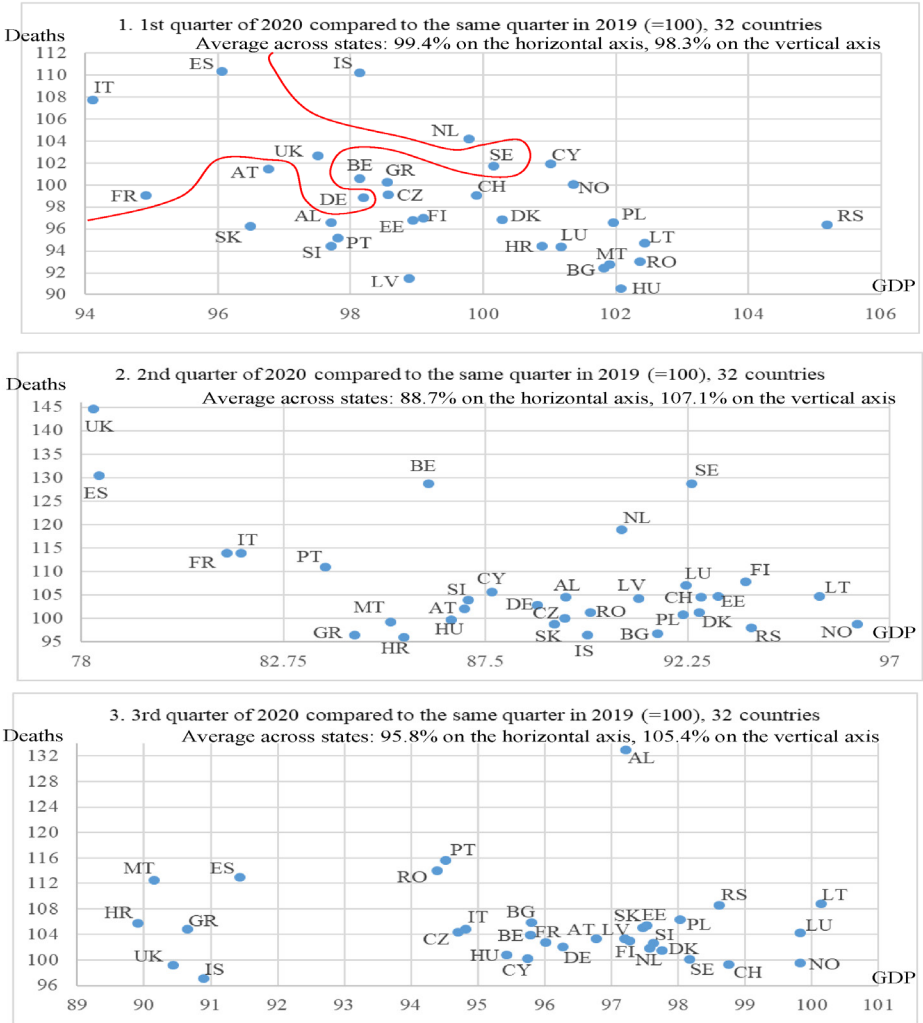
Key for country abbreviations: Albania (AL), Rep. of Ireland (IE), United Kingdom of Great Britain & Northern Ireland (UK). See also the key for country abbreviations provided in Table 1.

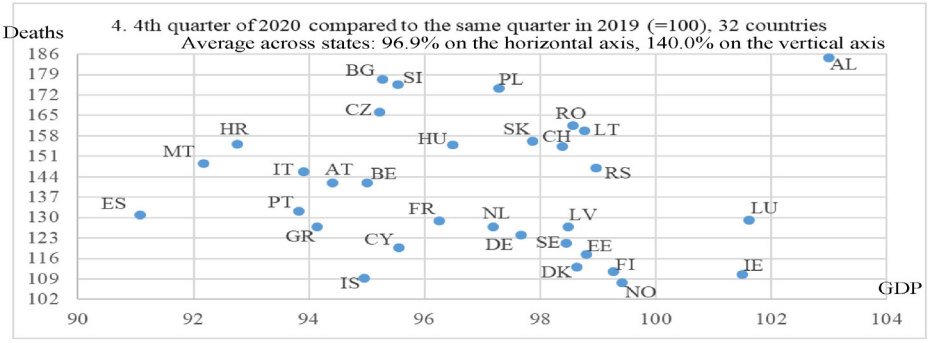
Note: WHO reports on the issue were incidental but became weekly from October 2020 onwards.

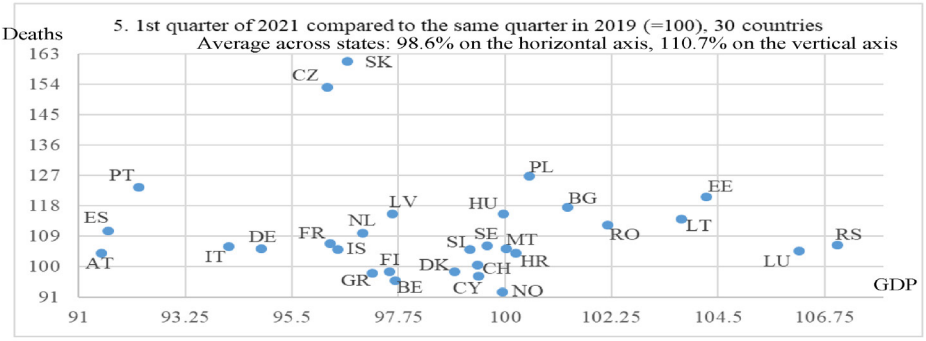
Source: WHO (2020a, 2020b, 2021). Author's own calculations.

Of the four types of responses, the one associated with the 4th quadrant is probably the most attractive, while that associated with the 2nd quadrant is probably the least attractive one, and the other two lie somewhere in-between. However, depending on people's values on suffering more (or fewer) deaths and achieving a higher (or lower) level of output, moving to a position in the 2nd quadrant close to the origin (e.g., the position of Greece) may be more attractive to positions (i.e., to coordinates) away from the origin in the 1st quadrant (e.g., the position of Sweden) or in the 3rd quadrant (e.g., the position of Germany or France). Alternatively, depending on people's values, moving to one of the latter combinations may be preferable to the former.

Figures 1-5. The evolution of the EU-member states and of six neighboring states in terms of real GDP (2015 values) and the total number of deaths during the pandemic, compared to the same quarter in 2019







Note: In Figure 1, the red colored curve distinguishes between the countries affected in January 2020 (situated above or to the left side of the curve) and the counties affected in February or March of 2020 (situated below or to the right of the curve).

Key for country codes: See Tables 1 and 2.

Source: See Table 1.

On average, during 2020^{Q2} output dropped and mortality rose compared to 2019^{Q2}, and all countries went down a path of reduced output (Figure 2): In about two thirds of the countries mortality increased (2^{nd} quadrant), and in the rest it decreased (3^{rd} quadrant). The latter comprised two of the eleven countries that had previously reached the 3^{rd} quadrant (Czechia, Slovakia), two of the eight countries that had previously reached the 2^{nd} quadrant (Greece, Iceland), five of the ten countries that had previously reached the 4^{th} quadrant (Malta, Bulgaria, Serbia, Croatia, Hungary), and one of the three countries that had previously reached the 1^{st} quadrant (Norway). As a result, mortality and output dropped in Norway, Iceland, and along a belt running from Czechia and Slovakia, through Hungary, Croatia, Serbia and Bulgaria to Greece and Malta (3^{rd} quadrant), while mortality rose and output fell considerably in the United Kingdom and Spain, and to a lesser extent, in the other countries under consideration (2^{nd} quadrant).

On average, during 2020^{Q3}, output dropped, and mortality rose compared to 2019^{Q3}, while more countries switched to the path already followed by the majority in 2020^{Q2} (Figure 3). However, the pace differed: mortality rose considerably in Albania; output dropped considerably in Spain, Malta, Greece, and Croatia; and both variables presented modest change elsewhere (2nd quadrant). At the same time, mortality and output rose in Lithuania (1st quadrant) and fell in four non-EU states: the United Kingdom, Switzerland, Iceland, and Norway[5] (3rd quadrant).

On average, during 2020^{Q4}, output dropped, and mortality rose compared to 2019^{Q4}, as nearly all countries went down the path already followed by the majority (Figure 4). In particular, mortality rose and output dropped in 29 out of 32 countries for which data exist (2nd quadrant)[6]. Of these, one country, namely, Norway, operated close to pre-pandemic levels in terms of *both* output and overall mortality. By contrast, mortality and output rose in the Republic of Ireland, Luxembourg, and Albania (1st quadrant).

By the end of the year the highest numbers of confirmed SARS-CoV-2 deaths per 100 thousand people were reported in Belgium, Slovenia, and Italy, and the lowest in Cyprus, Iceland, and Norway. At about the same time –in the second week of December in the UK and in the last week of December in the EU– mass immunization campaigns were launched, and the pace picked up in the months that followed. However, the number of deaths due to the infection continued to rise. By the end of 2021^{Q1}, the highest numbers of confirmed SARS-CoV-2 deaths per 100 thousand people were reported in Czechia, Slovenia, and Hungary, and the lowest in Finland, Norway, and Iceland (Table 2, columns 2-3).

On average, during 2021^{Q1}, output dropped, and mortality rose compared to 2019^{Q1} and 2020^{Q1} (Figure 5). Out of the 30 countries for which data exist, 16 continued along the path of the previous quarter[7]. The rest went down different paths: i.e., combinations of mortality and output they had tried or had not tried before. Thus, mortality and output rose in a number of places, namely, Poland, Lithuania, and Estonia; in Romania, Bulgaria, Serbia, and Croatia; in Luxemburg, and in Malta (1st quadrant). At the same time, mortality and output dropped in Greece and Cyprus, in Denmark, Norway and Finland, and in Belgium (3rd quadrant), while output dropped and mortality rose along a belt stretching from Iberia and France, through Italy, Germany, Switzerland and Austria, to Hungary, Slovenia, Czechia, Slovakia, the Netherlands, Sweden, Latvia, and Iceland (2nd quadrant).

5. The United Kingdom previously operated in the 2nd quadrant, Switzerland in the 3rd and 2nd quadrants, Iceland in the 2nd and 3rd quadrants, Norway in the 4th and 3rd quadrants.
6. The data regarding the United Kingdom were not available at the time these lines were written.
7. The data regarding the United Kingdom, the Republic of Ireland, and Albania were not available at the time these lines were written.

On the whole, all ten countries that early in the pandemic had moved into the 4th quadrant (i.e., a state of higher output and lower mortality vis-à-vis 2019^{Q1}) soon switched to either the 2nd quadrant (i.e., a state of lower output and higher mortality vis-à-vis 2019^{Q2}) or to the 3rd quadrant (i.e., a state of lower output and mortality) and then to the 2nd quadrant. Luxemburg, Malta, Serbia, Bulgaria, Croatia, Romania, and Poland opted or managed to eventually move into the 1st quadrant (a state of higher output and mortality), Lithuania switched twice to (and ended up in) the 1st quadrant, Denmark moved into the 3rd quadrant, and Hungary remained in the 2nd quadrant. (See Table 3.)

Table 3. Summary of the developments in terms of output – mortality quadrants vis-à-vis the same quarter of 2019

	2020^{Q1}	2020^{Q2}	2020^{Q3}	2020^{Q4}	2021^{Q1}
LU	4	2	2	1	1
BG, HR, MT, RS	4	3	2	2	1
PL, RO	4	2	2	2	1
LT	4	2	1	2	1
DK	4	2	2	2	3
HU	4	3	2	2	2
NO	1	3	3	2	3
CY	1	2	2	2	3
SE	1	2	2	2	2
EE	3	2	2	2	1
FI	3	2	2	2	3
AL	3	2	2	1	//////////
CH	3	2	3	2	2
CZ, SK	3	3	2	2	2
DE, FR, LV, PT, SI	3	2	2	2	2
IS	2	3	3	2	2
GR	2	3	2	2	3
UK	2	2	3	//////////	//////////
BE	2	2	2	2	3
AT, ES, IT, NL	2	2	2	2	2
IE	//////////	//////////	//////////	1	//////////

Key for quadrant numbers and colors:
1 (dark gray): output, mortality ↑. 2 (black): output ↓, mortality ↑.
3 (light gray): output, mortality ↓. 4 (white): output ↑, mortality ↓.
Other fill: Information is not available.

Key for country codes: See Tables 1 and 2.

Source: See Table 1.

Of the three countries that, early in the pandemic, had moved to the 1st quadrant, Sweden and Cyprus soon switched to the 2nd quadrant. Sweden maintained its position, and Cyprus eventually moved to the 3rd quadrant. By contrast, Norway moved to the 3rd quadrant, then the 2nd, and back to the 3rd.

All ten countries that early in the pandemic moved to the 3rd quadrant, sooner or later switched to the 2nd. Of these, France, Germany, Czechia, Slovakia, Slovenia, Latvia, and Portugal maintained their positions, Switzerland moved briefly to the 3rd quadrant and back, while Finland eventually moved to the 3rd quadrant and Estonia, eventually, to the 1st.

Of the seven countries that initially dealt with the pandemic under 2nd quadrant conditions, Spain, Italy, Austria, and the Netherlands maintained their positions; Iceland and Greece moved twice to (and Greece ended up in) the 3rd quadrant, while Belgium moved to the 3rd quadrant at the end of the period under consideration.

4. Econometric findings

To probe into the factors that may have influenced the choices and performance presented above, and even isolate one effect from another, we turn to the econometric examination of the two indices, namely, quarterly output and mortality during the pandemic vis-à-vis the same quarter in 2019, in terms of each country's population, area (acreage), per capita GDP, poverty/social exclusion figures, and number of confirmed SARS-CoV-2 deaths, both in level-level and log-log form. As the number of confirmed SARS-CoV-2 deaths is available only for three of the five quarters, we focus on 2020^{Q2}, 2020^{Q4} and 2021^{Q1}. Mindful of the limited degrees of freedom, we only engage in tri-variate analyses and report the best fits.

Table 4. The seemingly unrelated regressions (SURs) at the quarterly level of real output in million euro (2015 values) and of the quarterly number of deaths, each divided by the respective figure of the same quarter in 2019 (termed below x^1 and x^2, respectively), in the EU-27 states and six neighboring states during the SARS-CoV-2 pandemic

	Dependent variables	SURs of 2020^{Q2} $Ln(x_1)$ (1)	x_2 (2)	SURs of 2020^{Q4} $Ln(x_1)$ (3)	x_2 (4)	SURs of 2021^{Q1} $Ln(x_1)$ (5)	x_2 (6)
Independent variables							
1	Constant (refer. areas)	4.26	96.65	4.64	157.29	4.71	92.03
2	Aggregate number of confirmed SARS-CoV -2 deaths per 100,000 pop. reported at the end of the quarter		0.42				0.11
3	Real per capita GDP in thousand euro in the same quarter in 2019; based on the population figure of 1.1.2019				-6.39		
4	Squared value of the previous variable				0.22		
5	Ln (annual number of people at the risk of poverty or social exclusion in 2018)	0.09					
6	Ln (variable #3)			-0.08		-0.12	
7	Squared value of the previous variable	-0.01		0.02		0.03	
8	Spatial dummies	-0.07[a]	8.44[b]	-0.04[c]	28.44[d]	-0.05[e]	22.24[f]
	R^2	88.36%	93.02%	84.68%	86.75%	75.41%	70.22%
	N	32[g]		32[h]		30[i]	

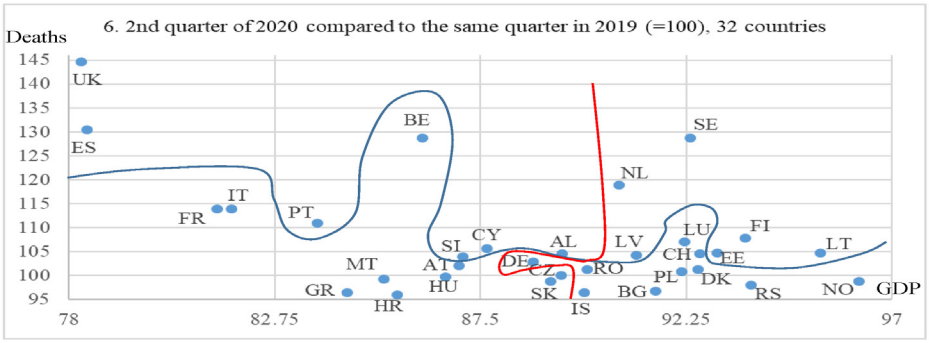
a AL, AT, BE, CY, CZ, ES, FR, GR, HR, HU, IT, MT, PT, SI, SK, UK.
b AL, CY, EE, ES, FI, LT, LV, NL, PT, SE, SI, UK.
c AT, BE, BG, CH, ES, GR, HR, IS, IT, MT, PT.
d AL, AT, BE, BG, CH, CZ, HU, IT, LT, MT, NL, PL, RO, SI, SK.
e AT, BG, CH, CZ, DE, ES, FR, GR, IS, IT, LV, NL, PT, SK.
f CZ, EE, IS, LV, PL, PT, SK. g Excluding IE (missing data).
h Excluding UK (missing data). i Excluding AL, IE, UK (missing data).

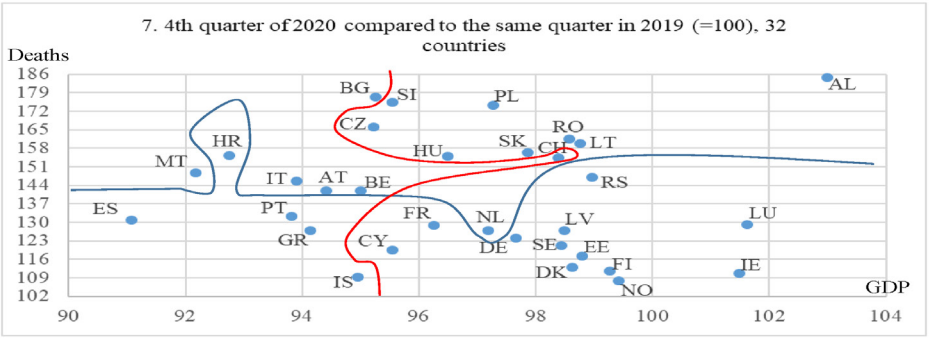
Notes: Country abbreviations are supplied in Tables 1-5. There were no WHO reports at the end of 2020^{Q1} and 2020^{Q3}, so variable #2 was not available for the said quarters. Additional regressors and both level-level and log-log expressions were considered in all cases. Only the best fits are presented. All P-values are equal to 0.0000.

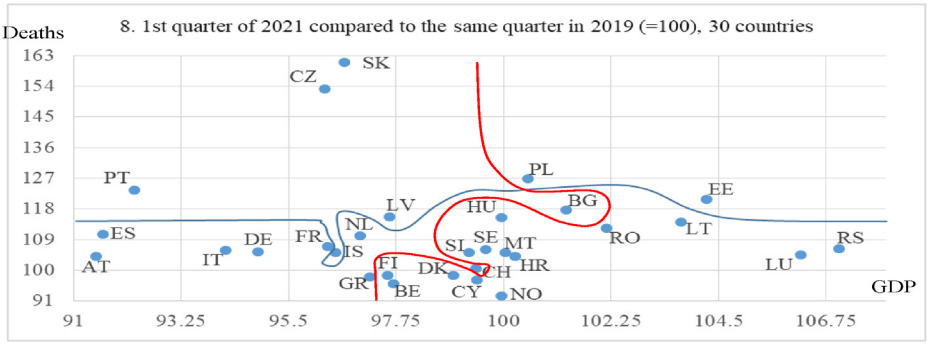
Sources: Variable #2: WHO (2020a, 2020b, 2021); other variables: Eurostat (the namq_10_GDP, demo_r_mwk_ts, demo_pjan$defaultview, and ilc_pers01n datasets as updated, respectively, on 6 June 2021, 17 June 2021, 27 April 2021, and 24 June 2021). Author's own calculations.

It turns out that in 2020^{Q2} (Table 4, columns 1-2) the mortality measure, x_2 was positively affected by the number of confirmed SARS-CoV-2 deaths per 100 thousand people, and by country-specific factors: Overall mortality was higher along a belt stretching from Iberia to the United Kingdom, the Netherlands, Sweden, Finland and the Baltic states, and in Cyprus, Albania, and Slovenia, for additional reasons. At the same time, the output measure, $Ln(x_1)$, was affected by socio-economic factors as proxied by the number of people at the risk of poverty or social exclusion during 2018, and by country-specific factors: Output was lower along a belt stretching from Iberia and France to Belgium, the United Kingdom, Italy, Malta, Greece, Cyprus, Albania, Croatia, Slovenia, Austria, Hungary, Czechia and Slovakia, for additional reasons. As a result, the shapes of the four quadrants appear somewhat *wavy* in terms of country-specific factors. (See Figure 6).

Figures 6-8. Redrawing the four quadrants of Figures 2, 4 and 5 in terms of the country-specific results of Table 4







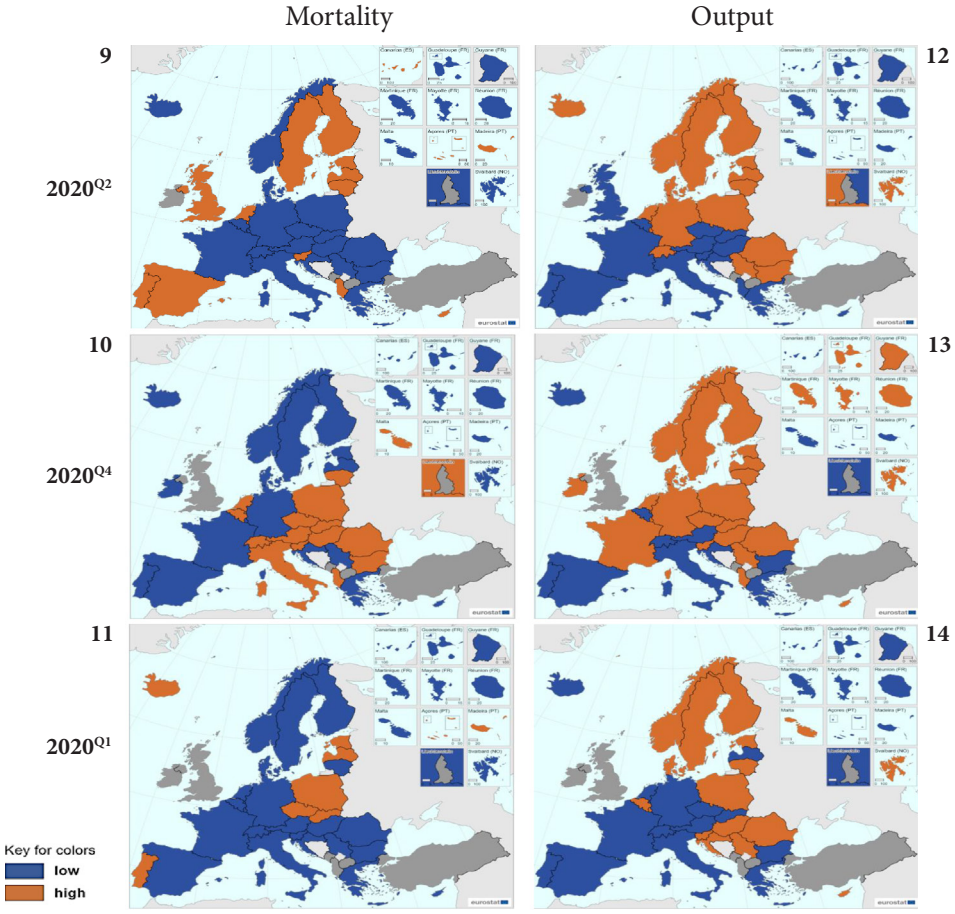
Likewise, the econometric analysis of the 2020^{Q4} indices (Table 4, columns 3-4) suggests that the mortality measure was negatively affected by the level of per capita GDP observed a year earlier, up to the amount of 14.6 thousand euro, positively affected by higher levels[8], and was also affected by country-specific factors: Overall mortality was higher along a belt stretching from Lithuania and Poland to Czechia, Slovakia, Austria, Hungary, Romania, Bulgaria, Albania, Italy, Malta, Slovenia, Switzerland, and in Belgium and the Netherlands, for additional reasons. At the same time, the output measure was affected by living standards, as proxied by the per capita GDP mentioned above, and also by country-specific factors: Output was lower along a belt stretching from Iberia to Italy, Malta, Greece, Bulgaria, Croatia, Austria, Switzerland, as well as in Belgium, and Iceland, for additional reasons. See Figure 7.

Last but not least, the econometric analysis of the 2021^{Q1} indices (Table 4, columns 5-6) suggests that the mortality measure was positively affected by the number of confirmed SARS-CoV-2 deaths per 100 thousand people, and also by country-specific factors: Overall mortality was higher in Poland, Czechia and Slovakia, in Latvia and Estonia, in Portugal, as well as Iceland, for additional reasons. At the same time, the output measure was affected by living standards, as proxied by the per capita GDP mentioned above, and also by country-specific factors: Output was lower along a belt stretching from Iberia to France, Germany, the Netherlands, Switzerland, Italy, Greece, Bulgaria, Austria, Czechia and Slovakia, as well as in Latvia, and Iceland, for additional reasons. See Figure 8.

For illustrative purposes, the spatial patterns of the said additional country-specific factors are presented in Figures 9-14.

8. The minimum value of 14.6 thousand euro results from examining the function via the, so-called, first order conditions (i.e., the differentiation) with respect to per capita GDP.

Figures 9-14. The spatial patterns of the country-specific results obtained via the econometric analysis (Table 4)



Note: The template is provided by Eurostat. Any presentational imperfections are inherent to the template, for instance Málaga and Ceuta are missing altogether.

5. Discussion

The novel virus infection reached the EU in the last week of January 2020 and, subsequently (in seven-to-eight weeks), spread to the rest of the EU and the six neighboring countries studied in the article. As a result, the virus affected counties for unequal lengths of time –one country for two months, another for three weeks– during 2020^{Q1}. We should keep this aspect in mind when comparing the 2020^{Q1} output and mortality indices (especially infection-related mortality indices) across-countries.

The steps taken to deal with the pandemic, both in 2020^{Q1} and subsequently, disturbed economic life. Despite the steps taken, no country was able to avoid going through a low output-high mortality phase, and ten EU member states (including the four most populous ones) remained in this phase for nearly a year. These countries are Portugal, Spain, France, Italy, Slovenia, Austria, Germany, the Netherlands, Sweden, and Latvia. Though different in many respects[9], these countries are either adjacent to each other or have close maritime boundaries.

By contrast, all post-2020^{Q1} deviations from the low output-high mortality model occurred along a crescent-like spatial formation stretching from Ireland, Great Britain and Iceland to Belgium and Luxembourg, to Denmark and Norway, Finland, Estonia, Lithuania, Poland, Czechia, Slovakia, Hungary, the Balkans (Croatia, Serbia, Romania, Bulgaria, Greece, and Albania), Cyprus, Malta, and in Switzerland. These countries are also different in many respects[10]. By 2020^{Q4} in several of these countries the total number of deaths dropped below that of 2019 (pre-pandemic) quarterly levels[11], while in other countries output rose above respective 2019 quarterly levels[12]. Besides, as mass immunization campaigns commence or accelerated in 2021^{Q1}, so did economic activity in several of these countries[13].

However, this higher output was accompanied with increased human losses compared to pre-pandemic levels. In other countries, where output did not exceed pre-pandemic levels, the number of deaths dropped below respective 2019 levels[14].

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9. For instance, four countries (Germany, France, Italy, Spain) have populations of 46-83 million people (each), another four (the Netherlands, Sweden, Portugal, Austria) 8-17 million people (each), while two (Slovenia, Latvia) have smaller populations.
10. For instance, two countries (the United Kingdom, Poland) have populations of 38-66 million people (each), six (Romania, Belgium, Greece, Czechia, Hungary, Switzerland) 8-20 million people (each), while the rest have smaller populations. Some of these countries were infected by the novel virus early on, while others were infected later or were the last ones to be infected. Some suffered huge loss of life, while others suffered much less. Some constitute longtime members of the EU (including the EU headquarters), while others are relatively new members, and the rest are not members. Some opted for or managed to reach combinations of reduced output and mortality vis-à-vis the pre-pandemic era, while others did the exact opposite or switched from one situation to the other.
11. This occurred: (a) along a geographic belt of EU and non-EU states stretching from Czechia, Slovakia, Hungary, through Croatia, Serbia, Bulgaria, down to Greece and Malta during 2020^{Q2}, (b) in the non-EU states of the United Kingdom and Switzerland during 2020^{Q3}, and (c) in the two non-EU states of Norway and Iceland during both 2020^{Q2} and 2020^{Q3}.
12. This occurred in Lithuania in 2020^{Q3}, and in Luxembourg, the Republic of Ireland and Albania in 2020^{Q4}.
13. Namely, Bulgaria, Romania, Serbia, Croatia (in the Balkans), Poland, Lithuania, Estonia (in the northeastern EU), Luxembourg, Malta. All but Estonia had managed to increase output and reduce human losses a year earlier.
14. This occurred in Belgium, Greece and Cyprus, Finland, Norway and Denmark.

These patterns may be attributed to several factors associated either with aspects regarding the spread of the virus and the responsiveness of the healthcare systems (proxied by the number of confirmed SARS-CoV-2 deaths), or living standards, socio-economic or other characteristics, and may be better investigated when more observations and data become available. However, it seems that there also exist additional country-specific effects, i.e., effects likely to capture cultural aspects or policy-maker preferences and abilities. In most counties these effects varied from one quarter to the next during the pandemic, which may suggest short-term priority shifts –not necessarily changes in the overall strategy, especially if the strategy was to alternate between (a) lockdowns, in order to slow the spread of the virus, and (b) quick re-opening of the economy as soon as the number of deaths subsided, in order to contain the economic downturn. Furthermore, in the cases of Norway, Serbia, and Luxembourg, the effects consistently feature 4th quadrant characteristics (combining higher output and lower mortality), and in the case of Greece the effects consistently feature 3rd quadrant characteristics (i.e., lower output and mortality). All four countries are small or medium-sized in terms of population[15], which may suggest that the day-to-day management may have been easier. We will know what exactly was done differently when we compare the policies carried out (including the manner of implementation) in these and in other countries. This finding also lends strength to an argument that some countries repeatedly sought to meet both welfare goals, while other countries repeatedly gave precedence to preventing the loss of life. Interestingly, none of the counties considered in the article appears to have attempted –let alone achieved– to go beyond slowing the spread of the virus, by eliminating the transmission of the virus altogether. All these issues are worth revisiting when more data regarding 2020 and the first quarter of 2021 become available.

6. Conclusions

As more data on what transpired in 2020 and 2021 become available and are studied, knowledge on pandemic economics will advance. The article takes notice of spatial patterns across a large part of Europe and identifies a dominant low output-high mortality reaction, along with occasional deviations from it. It seems that the four most populous EU member states, along with six other EU member-states, did not (or were not able to) shift from the low output-high mortality situation for nearly a year. The econometric analysis suggests that the patterns and reactions may be explained in terms of country-specific and other factors. In a small number of countries, these

15. The three former host populations of 0.6-7 million people (each) and the latter hosts a population of 10-11 million people. Due to data limitations, we cannot tell whether the higher output-lower mortality approach was also observed in 2020^{Q2} and in 2021^{Q1} in the Republic of Ireland (pop. 5 million).

country-specific factors are consistent quarter after quarter. Since the countries are known, the next step is to find out what they did differently (big or small), so that if the situation ever re-appears, the same or something similar to what these countries did may be done. All in all, these findings, along with findings from the rest of world, will have to be looked at closer in order to identify paradigms and good practices, on the one hand, and develop more effective responses in case they are needed in the future, on the other.

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Appendix:

The combined GDP and deaths scores of 30 European states during the pandemic - (GDP score)^{w} x (total number of deaths score)$^{1-w}$

	2020^{Q1}									2020^{Q2}								
	w = 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
AT	0.42	0.40	0.37	0.35	0.33	0.31	0.29	0.27	0.25	0.78	0.74	0.70	0.66	0.63	0.60	0.57	0.54	0.51
BE	0.48	0.46	0.45	0.44	0.42	0.41	0.40	0.39	0.38	0.06	0.08	0.10	0.12	0.15	0.19	0.23	0.28	0.35
BG	0.88	0.86	0.84	0.82	0.79	0.77	0.75	0.73	0.71	0.95	0.92	0.90	0.87	0.85	0.83	0.80	0.78	0.76
CH	0.57	0.56	0.56	0.55	0.55	0.54	0.54	0.53	0.53	0.76	0.76	0.77	0.77	0.77	0.78	0.78	0.79	0.79
CY	0.44	0.46	0.48	0.50	0.51	0.54	0.56	0.58	0.60	0.70	0.67	0.65	0.63	0.61	0.59	0.57	0.55	0.53
CZ	0.55	0.53	0.51	0.50	0.48	0.46	0.45	0.43	0.42	0.85	0.82	0.79	0.77	0.74	0.71	0.69	0.66	0.64
DE	0.56	0.53	0.51	0.48	0.46	0.44	0.42	0.40	0.39	0.78	0.75	0.73	0.70	0.68	0.66	0.64	0.62	0.60
DK	0.67	0.66	0.64	0.63	0.62	0.60	0.59	0.58	0.57	0.84	0.83	0.83	0.82	0.82	0.81	0.81	0.80	0.80
EE	0.66	0.63	0.60	0.57	0.55	0.52	0.50	0.48	0.46	0.75	0.76	0.77	0.77	0.78	0.79	0.80	0.80	0.81
ES	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FI	0.65	0.62	0.60	0.58	0.55	0.53	0.51	0.49	0.47	0.67	0.69	0.71	0.73	0.75	0.77	0.79	0.81	0.83
FR	0.47	0.38	0.31	0.25	0.20	0.17	0.13	0.11	0.09	0.43	0.39	0.35	0.32	0.28	0.26	0.23	0.21	0.19
GR	0.50	0.49	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.89	0.80	0.72	0.64	0.58	0.52	0.47	0.42	0.38
HR	0.78	0.76	0.74	0.72	0.70	0.68	0.66	0.65	0.63	0.91	0.83	0.76	0.69	0.63	0.58	0.53	0.48	0.44
HU	0.97	0.94	0.91	0.88	0.85	0.82	0.79	0.77	0.74	0.84	0.78	0.73	0.69	0.64	0.60	0.56	0.53	0.50
IS	0.01	0.02	0.03	0.04	0.06	0.08	0.12	0.17	0.25	0.95	0.91	0.87	0.83	0.80	0.76	0.73	0.70	0.67
IT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.40	0.36	0.33	0.30	0.27	0.25	0.23	0.21
LT	0.79	0.78	0.78	0.77	0.77	0.77	0.76	0.76	0.76	0.76	0.78	0.80	0.82	0.84	0.86	0.88	0.91	0.93
LU	0.79	0.77	0.75	0.73	0.72	0.70	0.68	0.67	0.65	0.69	0.70	0.71	0.72	0.73	0.73	0.74	0.75	0.76
LV	0.88	0.81	0.75	0.69	0.64	0.59	0.55	0.50	0.47	0.76	0.75	0.75	0.74	0.74	0.73	0.73	0.72	0.72
MT	0.87	0.85	0.83	0.81	0.79	0.77	0.76	0.74	0.72	0.83	0.76	0.70	0.64	0.59	0.54	0.50	0.46	0.42
NL	0.33	0.34	0.36	0.38	0.40	0.42	0.44	0.46	0.49	0.36	0.39	0.42	0.45	0.48	0.52	0.56	0.60	0.64
NO	0.53	0.55	0.56	0.57	0.58	0.60	0.61	0.63	0.64	0.93	0.94	0.94	0.95	0.96	0.97	0.98	0.98	0.99
PL	0.70	0.70	0.70	0.70	0.70	0.70	0.71	0.71	0.71	0.85	0.84	0.83	0.82	0.81	0.81	0.80	0.79	0.78
PT	0.71	0.65	0.60	0.55	0.51	0.47	0.43	0.39	0.36	0.53	0.50	0.47	0.44	0.41	0.38	0.36	0.34	0.32
RO	0.86	0.85	0.84	0.82	0.81	0.80	0.78	0.77	0.76	0.83	0.80	0.78	0.76	0.74	0.72	0.70	0.68	0.67
RS	0.73	0.76	0.78	0.81	0.84	0.87	0.90	0.93	0.97	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.88	0.87
SE	0.45	0.46	0.47	0.48	0.49	0.50	0.51	0.52	0.53	0.06	0.08	0.11	0.15	0.20	0.26	0.34	0.45	0.59
SI	0.73	0.67	0.61	0.56	0.51	0.47	0.43	0.39	0.35	0.74	0.70	0.67	0.64	0.61	0.59	0.56	0.53	0.51
SK	0.63	0.56	0.50	0.44	0.39	0.35	0.31	0.27	0.24	0.88	0.84	0.81	0.78	0.74	0.71	0.68	0.65	0.63

Key for country codes: See Table 1.
Source: See Table 1.

Appendix (continued)

	2020^{Q3}									2020^{Q4}								
	w = 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
AT	0.62	0.57	0.53	0.49	0.46	0.42	0.39	0.37	0.34	0.49	0.46	0.44	0.42	0.40	0.38	0.36	0.35	0.33
BE	0.60	0.57	0.54	0.51	0.49	0.46	0.44	0.41	0.39	0.49	0.48	0.46	0.45	0.44	0.42	0.41	0.40	0.38
BG	0.51	0.50	0.48	0.47	0.46	0.44	0.43	0.42	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH	0.86	0.84	0.82	0.80	0.78	0.76	0.75	0.73	0.71	0.36	0.39	0.41	0.45	0.48	0.52	0.56	0.60	0.64
CY	0.78	0.73	0.68	0.64	0.60	0.56	0.52	0.49	0.45	0.78	0.73	0.68	0.63	0.59	0.55	0.52	0.49	0.45
CZ	0.58	0.56	0.54	0.51	0.49	0.47	0.45	0.43	0.41	0.18	0.19	0.21	0.23	0.25	0.28	0.30	0.33	0.36
DE	0.72	0.71	0.70	0.69	0.68	0.67	0.65	0.64	0.63	0.75	0.74	0.72	0.71	0.69	0.68	0.66	0.65	0.64
DK	0.76	0.75	0.75	0.74	0.74	0.74	0.73	0.73	0.72	0.90	0.88	0.86	0.84	0.81	0.79	0.77	0.75	0.74
EE	0.57	0.58	0.60	0.62	0.64	0.65	0.67	0.69	0.71	0.85	0.84	0.82	0.81	0.80	0.78	0.77	0.76	0.75
ES	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FI	0.69	0.70	0.71	0.72	0.73	0.74	0.75	0.76	0.77	0.93	0.91	0.89	0.88	0.86	0.84	0.82	0.81	0.79
FR	0.67	0.65	0.63	0.61	0.59	0.57	0.55	0.53	0.51	0.67	0.65	0.63	0.61	0.58	0.56	0.55	0.53	0.51
GR	0.55	0.51	0.48	0.44	0.41	0.38	0.36	0.33	0.31	0.66	0.60	0.55	0.50	0.46	0.42	0.38	0.35	0.32
HR	0.48	0.42	0.37	0.33	0.29	0.26	0.23	0.20	0.18	0.30	0.28	0.26	0.24	0.23	0.21	0.20	0.18	0.17
HU	0.77	0.74	0.70	0.67	0.64	0.61	0.59	0.56	0.54	0.34	0.35	0.37	0.39	0.41	0.43	0.45	0.47	0.49
IS	0.90	0.82	0.74	0.67	0.61	0.55	0.50	0.45	0.41	0.89	0.80	0.73	0.66	0.60	0.54	0.49	0.45	0.41
IT	0.54	0.50	0.46	0.43	0.40	0.37	0.34	0.31	0.29	0.43	0.41	0.39	0.37	0.35	0.33	0.31	0.30	0.28
LT	0.40	0.43	0.46	0.49	0.52	0.56	0.60	0.64	0.68	0.28	0.31	0.35	0.39	0.43	0.48	0.53	0.59	0.66
LU	0.65	0.68	0.71	0.75	0.78	0.82	0.86	0.91	0.95	0.72	0.75	0.77	0.80	0.83	0.86	0.90	0.93	0.96
LV	0.67	0.67	0.68	0.68	0.68	0.69	0.69	0.70	0.70	0.72	0.72	0.72	0.72	0.71	0.71	0.71	0.71	0.71
MT	0.16	0.16	0.15	0.14	0.13	0.13	0.12	0.11	0.11	0.36	0.31	0.27	0.24	0.21	0.18	0.16	0.14	0.12
NL	0.73	0.71	0.69	0.68	0.66	0.64	0.63	0.61	0.59	0.71	0.69	0.68	0.66	0.65	0.63	0.62	0.61	0.59
NO	0.86	0.85	0.85	0.84	0.83	0.82	0.81	0.81	0.80	0.98	0.95	0.93	0.91	0.89	0.87	0.85	0.83	0.81
PL	0.51	0.52	0.53	0.53	0.54	0.55	0.56	0.57	0.58	0.06	0.08	0.10	0.13	0.16	0.21	0.27	0.35	0.46
PT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.54	0.49	0.45	0.41	0.37	0.34	0.31	0.28
RO	0.11	0.14	0.17	0.21	0.25	0.31	0.38	0.47	0.58	0.26	0.29	0.32	0.36	0.40	0.45	0.51	0.57	0.64
RS	0.41	0.44	0.47	0.50	0.54	0.57	0.61	0.66	0.70	0.46	0.49	0.51	0.54	0.57	0.60	0.64	0.67	0.71
SE	0.83	0.81	0.80	0.78	0.77	0.75	0.74	0.73	0.71	0.80	0.79	0.77	0.76	0.75	0.74	0.73	0.72	0.71
SI	0.67	0.64	0.60	0.57	0.55	0.52	0.49	0.47	0.45	0.04	0.05	0.06	0.08	0.11	0.14	0.19	0.25	0.32
SK	0.58	0.59	0.59	0.60	0.61	0.61	0.62	0.63	0.64	0.33	0.35	0.38	0.41	0.44	0.48	0.51	0.55	0.60

Appendix (continued)

	2021[Q1]								
	w = 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
AT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BE	0.87	0.80	0.73	0.67	0.62	0.57	0.52	0.48	0.44
BG	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
CH	0.84	0.79	0.75	0.71	0.67	0.64	0.60	0.57	0.54
CY	0.88	0.83	0.78	0.73	0.69	0.65	0.61	0.58	0.54
CZ	0.13	0.14	0.15	0.17	0.19	0.21	0.23	0.25	0.28
DE	0.71	0.62	0.55	0.48	0.42	0.37	0.32	0.28	0.25
DK	0.86	0.80	0.75	0.71	0.66	0.62	0.58	0.55	0.51
EE	0.61	0.63	0.65	0.67	0.70	0.72	0.74	0.77	0.80
ES	0.48	0.31	0.20	0.13	0.08	0.05	0.03	0.02	0.01
FI	0.84	0.77	0.71	0.65	0.60	0.55	0.51	0.46	0.43
FR	0.72	0.66	0.60	0.54	0.50	0.45	0.41	0.38	0.34
GR	0.84	0.77	0.70	0.64	0.58	0.53	0.48	0.44	0.40
HR	0.80	0.77	0.74	0.71	0.69	0.66	0.63	0.61	0.59
HU	0.65	0.64	0.63	0.61	0.60	0.59	0.58	0.57	0.56
IS	0.74	0.68	0.62	0.56	0.51	0.47	0.43	0.39	0.35
IT	0.69	0.59	0.51	0.44	0.37	0.32	0.28	0.24	0.20
LT	0.69	0.70	0.71	0.72	0.73	0.74	0.76	0.77	0.78
LU	0.84	0.85	0.86	0.87	0.88	0.90	0.91	0.92	0.94
LV	0.63	0.60	0.57	0.54	0.51	0.49	0.46	0.44	0.42
MT	0.78	0.75	0.72	0.70	0.67	0.64	0.62	0.60	0.57
NL	0.69	0.64	0.60	0.55	0.51	0.48	0.44	0.41	0.38
NO	0.94	0.89	0.83	0.78	0.74	0.70	0.65	0.62	0.58
PL	0.51	0.51	0.52	0.53	0.54	0.55	0.55	0.56	0.57
PT	0.43	0.34	0.27	0.21	0.17	0.13	0.10	0.08	0.06
RO	0.71	0.70	0.70	0.70	0.70	0.70	0.69	0.69	0.69
RS	0.82	0.83	0.85	0.87	0.89	0.91	0.93	0.96	0.98
SE	0.77	0.74	0.71	0.68	0.65	0.62	0.60	0.57	0.55
SI	0.78	0.74	0.71	0.67	0.64	0.61	0.58	0.55	0.53
SK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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PRIVATIZATION THROUGH CONCESSION AND THE PERIL TO PUBLIC INTEREST - THE CASE OF "EGNATIA HIGHWAY"

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Abstract
This paper focuses on the financial and developmental effects of privatization of public infrastructure projects through based on the case study of 'Egnatia Highway' that connects the port of Igoumenitsa in Western Greece with the Greek-Turkish borders in Thrace. Following an informative chronicle of the creation of the 'Egnatia Odos', in the second part of the manuscript, we develop the theoretical framework of our analysis by studying the history and the effects of similar concession projects in Greece and abroad. Specifically, we discuss the Morandi Bridge in Genoa, the motorway around Strasbourg, public roads in Croatia, as well as similar cases outside Europe and Latin America, in particular. In the main part of the study, we present a detailed analysis of the intended 35-year concession of 'Egnatia Odos' based on data from past years and official forecasts concerning the operation, maintenance and commercial exploitation of the specific public asset. Our analysis reveals that avoiding the concession and sustaining public management benefits public interest, Greek society, and the economy. Data prove that public management will generate significantly higher profits for the State while keeping the toll charges at lower levels. At the same time, given the geo-economic significance of the highway in the light of collective management in the Balkans, controlling the specific asset is of exceptional national economic importance.

JEL Classification: R42, H41, H43
Keywords: Privatization vs Public Management, Concession of Public Infrastructure Projects, Regional Development

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1. Introductory remarks and the history of the specific infrastructure project

Egnatia Highway (EO) is the main horizontal road axis, of a total length of 657 km, that crosses Northern Greece from the port of Igoumenitsa to the main Greek-Turkish border at Kipoi. Construction works started in 1977 and were completed more than a decade ago. This is a closed highway of international standards, with two traffic lanes and an emergency lane per direction, separated by a median strip. This is an extremely important infrastructure investment of transnational significance for the development of the region it crosses.

Given the directives of the EU in order to finance this ambitious project and the realization that this was the best way to overcome bureaucratic tie-ups of the Greek public sector, "Egnatia Odos S.A." (EO), 100% owned by the Greek State, was established in 1995; its purpose was to complete the construction and to undertake the operation and maintenance of the highway. EO was supervised by the Ministry of the Environment, Planning and Public Works. Observing the policies following the last financial crisis (from 2011 and onwards), the Hellenic Republic Asset Development Fund (HRADF, https://www.hradf.com/en/) was appointed by the Ministry of Finance to have the right to vote at the General Assembly of EO, in order to initiate and implement the concession of the operation, maintenance and exploitation of EO.

The total budget for the completion of the main axis (including design, construction, expropriations, and administrative/operational costs) came to approximately €5.6 billion (excluding VAT). If we include the Vertical Axes connecting the highway to the main northern gates to South-Eastern Europe the figure comes to approximately €7 billion, co-financed by EU (2nd and 3rd Community Support Framework) and national resources, mainly with loans provided by the European Investment Bank (EIB) to the Greek State (Ministry of Finance), as well as by private Greek financial institutions to EO. All the loans to the Greek banks were recently repaid by EO[1], while the debt to the EIB (total initial budget of €2.24 billion) is still being paid by the Ministry of Finance[2].

The implications of EO are quite significant and already visible (http://observatory.egnatia.gr). Regarding accessibility, there are direct benefits for the five main transit regions - Epirus, Western Macedonia, Central Macedonia, Eastern Macedonia & Thrace, Thessaly – with 10 border stations at four cross-national connections to Albania, North Macedonia, Bulgaria, and Turkey. The main axis connects 11 Greek

1. Repayment included all bank claims, although there is still a pending legal dispute concerning the total amount of the debt.
2. It should be noted that despite the intended privatization (concession) of EO, the Greek State will continue the pay back the construction loan to the EIB, although the asset and its exploitation will be granted to the private sector.

cities – Igoumenitsa, Ioannina, Metsovo, Grevena, Kozani, Veroia, Thessaloniki, Kavala, Xanthi, Komotini, Alexandroupolis with each other and with four ports and six airports. Moreover, Egnatia Odos is a transport link connecting 48 organized manufacturing zones (including industrial areas and parks, industrial business estates, steam power plants, logistics centers, etc.); this is extra evidence to the economic importance of the motorway. Last, but not least, with respect to its cultural effects, EO facilitates access to 85 archaeological sites, 75 museums, 78 places of distinct natural beauty, more than 250 traditional villages, resorts, and facilities hosting cultural events. Finally, road safety has been substantially improved as EO is 5 times safer than the alternative road network (old national roads). Comparing the years before with those after EO operation (data till 2011), it appears that in the major road networks of Northern Greece there is a more than 70% reduction in the number of motor accidents, while fatal injuries also dropped by 60%.

This case study exhaustively analyses the financial and developmental aspects of the project and evaluates the implications of its concession for the public interest. For this reason, the authors sum up the detailed analysis in the report conducted in December 2020 with the support of the Association of EO Employees (https://syllogosseteo.files.wordpress.com/2020/12/09dek2020_main_study_final.pdf).

2. Worldwide and Greek painful experiences from concessions of public interest infrastructure projects

Starting with the international experience, we have chosen four European cases and one from Latin American. Morandi Bridge is perhaps one of the most familiar examples. The bridge did much more than simply connect the eastern with the western part of Genoa. The bridge used to be an architectural asset of the city, the birthplace of Christopher Columbus, that hosts the largest commercial port of Italy. Ricardo Morandi built the bridge in the 1960s introducing, thereby, a multitude of aesthetic and construction innovations that made it one of the most beautiful bridges in Italy.

In 1999, the maintenance and exploitation of Morandi Bridge was transferred to the company Autostrade d' Italia, owned by Atlantia, which is owned by the holding company Edizione that, in turn, belongs to the well-known Benetton family. Along with Morandi Bridge, the same family took control of nearly half of the motorways of the whole country for a period up to 2038. At that time this was considered the epitome of innovation and the brave modern entrepreneurial spirit. In the following years, the management of infrastructure and motorways became extremely important for the holding company: in 2019, 42% of its total assets (€14 billion) came from this very activity, while the sale of clothing items (at 5,000 shops around the world with 8,000 employees) contributed a mere 4%!

During the same period, even in less wealthy countries than Italy, large scale works were carried out at similar bridges for maintenance purposes and, further-

more, for reinforcing their structural strength. In Genoa's case, on the contrary, well-documented concerns were publicly expressed about the over-exploitation of infrastructure, including Morandi Bridge: for instance, in 2003, Marco Pronti, Professor of Transport Economics at the Polytechnic University of Milan and adviser to the government, highlighted the issue of exorbitant increases in tolls paid by road users and stated that Autostrade is the second most profitable company in the world. Pronti also denounced the motorway lobby for blackmailing the state, threatening not to invest unless its demands for further toll increases were met. The professor concluded his interview stressing that "concessions are an automatic mechanism of corruption" (La Repubblica, 2003).

Specific concerns about the Genoa Bridge have been raised by other sources, too. Late in 2017 or early 2018, audits showed that the bridge had weakened from 10% to 20%, on average, as stated by a Supervising Engineer from the local Ministry of Infrastructure and Transport (Glanz, 2018, New York Times). According to the same person, a scientific article had also been published by an engineer from the University of Genoa, who recommended that the entire bridge should be replaced! Additionally, a relevant question was raised in the Italian Parliament on 20 October 2015, addressed to the Ministry of Transport and Infrastructure, which stated that "Autostrade company has the necessary financial resources, from tariff increases alone, as agreed on in the concession approved, in order to start the necessary works" (Senato de la Repubblica, 2015). Nevertheless, the concessionaire did not respond at all, despite constant protests by the residents around the motorway leading to Morandi Bridge, because the sound-proof panels were displaced by the strong winds causing accidents involving drivers and pedestrians! The result was disastrous: on 14 August 2018, Genoa Bridge collapsed causing the death of 43 civilians in a pre-announced tragic accident.

Justifiably, public reactions were extremely severe – high-ranking government officials argued for the revocation of the concession agreement and demanded the imposition of fines of hundreds of million euros for the criminal negligence of the concessionaire Autostrade d' Italia (Kathimerini, 2018). Nonetheless, the license to Autostrade (Glanz, 2018) was renewed by the Parliament.

In case someone would argue that the case of Genoa Bridge may have been an extreme, yet non-representative example, there are also other similar cases: "*after cracks were observed in a tunnel northwest of Genoa that partially collapsed last year, Italy's Ministry of Transport ordered a thorough inspection of the region's elevated crossings and bridges. Almost all had safety problems and had to be repaired*" (Panigiani, 2020). The example of the Genoa Bridge, which is not the only one, essentially contradicts the public interest nature of conceding infrastructure of strategic public interest and, in particular, motorways. The same conclusion can be drawn if we consider three additional European cases. In England, a thorough investigation assessed the governmental promises that justified concessions: "*the government has justified its*

policy in two ways. First, the use of private financing, despite inherently higher costs, would provide the investment that the public sector could not afford. Secondly, it would maximize the (value for money), a concept that means lower lifetime costs, including the cost of transferring risk, compared to the conventional government procurement. The article presents the accounting and financial data to analyze the investment, costs including the cost of using private capital in order to assess the government's allegations. The conclusion was that the concessions were "proved to be more expensive than expected, thereby cancelling the cost advantage". In addition, "*our analysis shows that the cost of risk transfer was very expensive*" (Shaoul, *et. al.*, 2006).

In France, reactions were provoked when there was an announcement that a modern motorway around Strasbourg is to be built, using the concession method, by the French multinational company "Vinci", which will run it for 55 years. The project met with unequivocal reactions by local movements and environmental organizations, due to the damage it will cause to the environment, threatening the survival of rare and protected species, public health and climate (Counter-Balance, 2020).

In Croatia, in October 2014, an alliance of seven unions and seven civilian-society organizations was formed to collect the necessary number of signatures in a petition for a referendum in order to incorporate the following article in a law being discussed at the time by the parliament: "*public roads are of strategic interest and are prohibited to be offered to concessions*". The reason that led to this mobilization was the expressed willingness of the government to seek a concessionaire for 1,017 km of modern highways, constructed in the early 2000s at a cost of €5,8 billion. Taking into account the draft-tender, the concession would be granted for 35-40 years, and bidding would start at 2.4 billion with a ceiling of €3.2 billion (Milekic, 2014).

Outside Europe and, specifically, in Latin America, where concessions began in the 1970s and 1980s guided by the World Bank, more serious economic crimes have been recorded. An extreme but illustrative example is the bail out by the State of the concessionaire who took over Mexico highways in the early 1990s. The estimate for the concessionaire's rescue cost is 7- 12 billion dollars, in other words 1% to 1.7% of the country's GDP (Guasch, et. al. 2007)! In conclusion, many examples around the world make it clear that concessions have been the foundation of high ephemeral profits to the detriment of the public and citizens-users, leading, at the same time, to the technical downgrading and rapid devaluation of public infrastructure.

If we now focus on Greece, concession contracts are considered a subcategory of Public-Private Partnerships (PPPs) and fall into the category of purely conventional PPPs. Unlike other types of contracts, according to which a company receives a fixed fee from the public for the implementation of a project or the provision of a service, in concessions the company's fee mainly comprises the concession of the project management and operation. The benefit concessionaires may bring to the public is related to the mobilization of private funds to complement public resources.

The form of concession was chosen for the construction and management of highways, vehicle parking facilities, marinas, and other infrastructure projects. The 1st generation of concession projects began in the 1990s and included Attiki Odos, Eleftherios Venizelos Airport and the Rio-Antirrio Bridge. The 2nd generation projects include the Olympia Road, the Ionian Road, the Central Road, the Aegean Highway and the Moreas Highway and were signed in 2007-2008. Among the concessions of the 3rd generation are the concession of Alimos Marina, the extension of the contract for Eleftherios Venizelos Airport, a double extension of Attiki Odos, expected to be procured in the first half of 2021, Kasteli Airport in Crete and other infrastructure projects under discussion.

The effect of the pandemic is an unprecedented recession, more intense than the one provoked by the recent financial and economic crisis. The successive waves of relief measures announced by the government did not prevent a massive wave of 'padlocks', especially in cases of small and medium enterprises (IME GSEVEE, 2020 – Institute of small enterprises - Hellenic Confederation of Professionals, Craftsmen & Merchants) or the reduction of the income of thousands of workers, since even those who joined aid programs (i.e. Co-Work), did not prevent cuts to their pay. An exception to the rule of generalized loss of income and even profits, proved once again to be the seven concessions that operate on Greek highways, namely: Olympia Odos (Elefsina - Corinth - Kalamata), Rio-Antirrio Bridge, Aegean Motorway, Central Road, Nea Odos, Moreas (Corinth - Tripoli - Kalamata) and Attiki Odos. The highways, despite taking advantage of opportunities opened by the public to mitigate the effects of the lockdown, like any other company, regardless of their financial size, are seeking compensation from the Greek Government, citing the loss of revenue recorded compared to 2019.

The seven concessionaires requested from the State a total amount of €83.41 million (Lialios, 2020). These claims directly contradict the interest of Greek taxpayers – even if they are provided for in the concession agreements, they are equivalent to a moral scandal and cannot be compared to the aid provided by the Greek Government to entrepreneurs. The difference is both qualitative and quantitative, as in this case we are dealing with a reimbursement of profits, similarly to the case of the Aegean airline company.

Past experiences convince us that the claim for compensation by private road operators is not an exception to a regime of orderly, predictable, and contractual relations – in fact, current concessionaires' claims can be characterized as the fourth episode in a series of similar claims in the last 15 years. The first episode began immediately after the agreements were approved by the Greek Parliament in 2008. The reasons were the obligations, undertaken by the Greek Government, to complete the archeological investigations and the expropriations in the provocatively short period of 1.5 years, which was absolutely impossible. Given that this phase lasted five years, the

state paid hundreds of millions in compensation (Kathimerini, 2013). "*The projects on the five highways are proving to be 'undermined' from the beginning, with the 2007 contracts causing a confusion of responsibilities, from which Contractors, Banks and the State are rushing to take advantage, each trying to load the others with the blame*" (Tzanavara 2010).

Even before the extra episodes of appreciation for concessions unfolded, "*a European record of cost and precision overruns characterizes specific Greek infrastructure projects, according to a Community report, exceeding of even 100% of the cost of Greek infrastructure projects are revealed. It is also estimated that in our country one kilometer of motorway is worth up to EUR 65 million, when the most expensive project in the other Community States is paid for by the State at most EUR 20 million per kilometer. On Attica Motorway from 9 million EUR per kilometer to the final 'bill' of 20 million per km*" (Kadda, 2009).

The second episode of the revision of concession agreements was during the Memorandum period, when the decrease in traffic led to a record drop in the income of concessionaires and banks, which entered a period of crisis and loan stagnation, reluctant to finance major projects. "*The 'juice' behind this banking policy is the interest rates. The loan agreements that were signed in 2007 ranged from 1% -1.5% when today in the interbank market they are around 5%. They claim that the financial model went bankrupt within four years and demand changes, seeking to secure future profits from the first "deviation" and hiding that the contracts expire in 2037, when much will have changed*" (Tzanavara, 2011).

The third episode occurred in 2016, when the Greek government was accused of not paying the public share on time with a long-term delay (toxrima.gr, 2016). It was estimated that the first three compensation episodes alone increased the actual cost of the projects by € 6 billion (Lialios, 2017)! Successive increases in the cost of public works borne by the concessionaires were criticized even by the European Court of Auditors: in their special report on Public-Private Partnerships, they stated that "*as a result of the payment of the State to the concessionaires and the significant increase of the financial costs, the total cost of the Olympia Odos project per kilometer increased by 69%, from 7.7 to 13 million euros. Meanwhile, the length of the highway to be built was reduced by 45%. Similarly, in the case of the Central Greece highway, the total cost of the project per kilometer increased by 47%, from 13.7 to 20.2 million euros per kilometer, while the highway to be constructed shrank by 55%. Overall, due to the restart, the total cost of the three motorways increased by 36%, from € 9.1 million to € 12.4 million per kilometer, and the EU contribution to the total project cost per kilometer increased by 95%, from € 2.1 EUR million per kilometer to € 4.1 million per kilometer*" (European Court of Auditors, 2018).

Last, but not least, there are certain scandalous financial aspects that can be drawn from concessionaires' published balance sheets. Our main observation relates

to revenues and how they were formed over time. In the 2012–2019 period under examination, the highways conceded was the industry that not only protected its revenues but even reported an upward trend.

Obviously, concessions did not reduce the costs for the Greek state and taxpayers or for highway users. On the contrary, concessions proved to be a source of easy super profits and a 'haven' for the shrinking construction sector in Greece (metaforespress.gr, 2020), at a time of shrinking wages and pensions and extreme financial uncertainty. Interestingly, the same trend is seen in the cost announced, which raises questions, since on an operating road axis there should not be major differences in operating costs. A closer look reveals that the depreciations undertaken were probably increased for accounting purposes[3]. Moreover, the construction, and in many cases the operation of the highway, has been subcontracted to corporate subsidiaries. It is obvious that pricing of services does not fall under the obligations of the law on public tender procedures, and it is freely decided on by the two contractual parties.

Another interesting observation concerns the significant fluctuations of loan interest rates. Regarding loans, restructured more than once, these are always accompanied by interest rate hedging agreements, i.e., protection from increases in Euribor, Libor, ECB, etc. As a practice in a period of interest rate increases, this seems to be reasonable, even at potential cost. In our case, however, with a steady decline in interest rates for more than seven years, this is a wrong choice or even a case of mismanagement. This is even less justified when banks also participate in the shareholding structure of concessionaires.

Concluding, besides the transaction with related subcontractors and possible overpricing, EBITDA is consistently receiving half of the sales in all concessions. Of the €1 paid by the user, 0.20 is VAT, 0.40 is earmarked for safety, operation and maintenance costs and the remaining €0.40 serves the concession contract and profits of the concessionaire. It turns out that such practices do not serve the public interest, while the user of the infrastructure receives services that could be provided at half the charge imposed.

3. Egnatia Highway: the project, operation and maintenance

EO, as part of the Trans-European Road Network, is one of the most modern and high-tech road axes in Greece. Based on relevant estimates, EO annual traffic load exceeds 3 billion vehicle-kilometers travelled.

3. It should additionally be noted that this is a matter of depreciation on fixed assets of the company acquired using government grants, loan funds with government collateral, operating income, and minimum equity.

In total, EO manages the operation and maintenance of an extensive motorway network of 916 km (including the vertical connecting axes[4]), undertaken by external Contractors appointed through the public open tendering procedures stipulated, and coordinated and supervised by EO staff.

The scope of these contracts includes:

i. Road maintenance (daily inspections and surveillance, rehabilitation/repair and improvement works including rapid repairs of dangerous faults/damage, fault reporting/damage caused by drivers through www.egnatia.eu website, winter maintenance, maintenance of 3,500 km of safety barriers, repainting of horizontal road signage and large or smaller information signs, restorations of inscriptions on walls and signs, restoration of cables and sabotage and cleaning services on the road, rest and parking areas).
ii. Road operation: 6 Traffic Control Centers operating on a 24-hour basis, 100 Electronic Variable Message Signs, 180 Variable Speed Limit Signs and 850 Electronic Traffic Lane Definition Signs, operating 800 SOS Telephones and 34 Weather Stations, 60 traffic measuring stations on the road network of Northern Greece and the traffic management system.

EO coordinates and supervises the contracts already established. Experts, engineers, and technicians guide and assist contractors, while, in parallel, they develop and implement important innovative applications for traffic safety, unhindered movement of vehicles, environmental policy, statistics and traffic data[5].

In the EO's 2019 financial statements, the acquisition value of fixed assets was €6.43 billion, referring to the total net amount spent for the construction of the main and vertical axes of EO up to 31/12/2019[6], not to mention that, apart from construction, there are other costs related to the development of the highway and, of course, the costs of expropriations, borne by the "Ministry of the Environment, Planning and Public Works" and handed over to EO.

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4. The entire network consists of motorway A2 "Egnatia Odos" 657 km, A25 "Lagadas – Serres – Promachonas" 96 km, A29 "Siatista – Kristallopigi" 70 km, A1 "Axios – Evzonoi" 60 km, A23 "Komotini – Nimfaia – Greek-Bulgarian border" 22 km and the "Aktio – Preveza" immersed tunnel with its access roads of 4.7 km.
5. EO staff developed important systems for centralized management of the highway – for instance: Traffic Measurement System of Northern Greece, Management of the Traffic Model of Northern Greece, Road (RMS) and Bridge (BMS) Maintenance Management Systems, Geotechnical Monitoring System, Basic Maintenance Management System (RMMS) and Road Claims (RCMS), User Road Damage Reporting System (MDNS), Transit License Management System (VPMS) and Electricity Invoice Management System (NRG Management System), Management System for Fixed Electromechanical Equipment, Operation of a Network Monitoring Center, Observatory, Promotion of Projects of Intelligent Transport Systems, and the content of the corporate Environmental Policy.
6. Nevertheless, EO, besides its main role, implements a number of other projects and provides services to other public bodies, either through assignment by the Greek State or through direct agreements with municipalities, prefectures, etc.

Cumulative depreciation by 31/12/2019 had amounted to €676.27 million (82.45 million in 2019 alone – keeping in mind that as depreciation is correlated to the financial exploitation of the asset, in our case it actually started in 2010). As the depreciation period – being determined by the Ministry of Finance – lasts for a maximum period of 50 years, after the fixed asset has been fully exploited, annual depreciation will be at least €128.69 million (dividing 6.43 billion by 50).

Since concession is neither legally nor institutionally required, nor do its operations generate financial losses or any non-financial net burden for public interest, it is absolutely reasonable to consider the net value of the asset to be sold as a minimum price. The acceptance of a lower offer would be irregular raising questions with respect to the seller's motives. In our case, the reasonable fair value for the concession of EO's assets is derived from the non-depreciated value of the investment - which on 31/12/2019 was €5.76 billion (subtracting cumulative depreciation from the acquisition value of fixed assets) – reduced by the non-depreciated value after the concession period (35 years in this case), when the highway will return to the public sector. Given the above, this will be €1.26 billion (calculated by deducting 128.69 million from the 5.76 billion and multiplying by 35). In other words, following the method of accounting valuation, the minimum price for the concession should be €4.50 billion.

EO also constructed the vertical axes connecting it to neighboring Balkan countries. Due to the increased percentage of EC contribution (60%), tolls were not allowed along the specific roads in the first years of their operation. This has temporarily changed as the Commission accepted the term that toll revenues from the vertical axes will only be used to serve the public debt of the country. Yet, this provisional arrangement is not provided for in the concession agreement, which stipulates that all revenues will be collected only by the concessionaire[7].

In fact, from 2016 to 2020, €33.23 million has been secured for debt repayment (note the strong decrease of traffic due to the pandemic in 2020). Given the following assumptions – (i) the initial traffic load in the concession period of 35 years to be at the level of the year 2019 with an annual increase of 1.5%; (ii) proportional charges, as foreseen in the concession contract, to rise from today's 0.024 up to 0.051 €/km (excluding VAT), and (iii) an initial reduction of traffic, due to increased tolls, by 10% – it turns out that, from the two vertical axes through Serres (A25) and West Siatista (A29) alone, the estimated revenue which could contribute to the reduction of public debt is €1.47 billion!

7. Today, all toll stations on the vertical axes are in operation, although issues of charging length costs are still pending.

4. Chronology of EO concession procedure by HRADF and the paradoxical project form

In June 2011, Egnatia Highway and its three main vertical axes were included in the public property portfolio to be privatized (2012-2015), in order to contribute towards the repayment of the country's public debt. At the end of the same year, EO supervision was handed to the newly established HRADF, which was to launch the concession of the operation, maintenance, and exploitation of the highway. In August 2012, the Inter-Ministerial Committee for Restructuring and Privatization (Government Gazette 2316B/10-8-2012) transferred the rights of EO to HRADF.

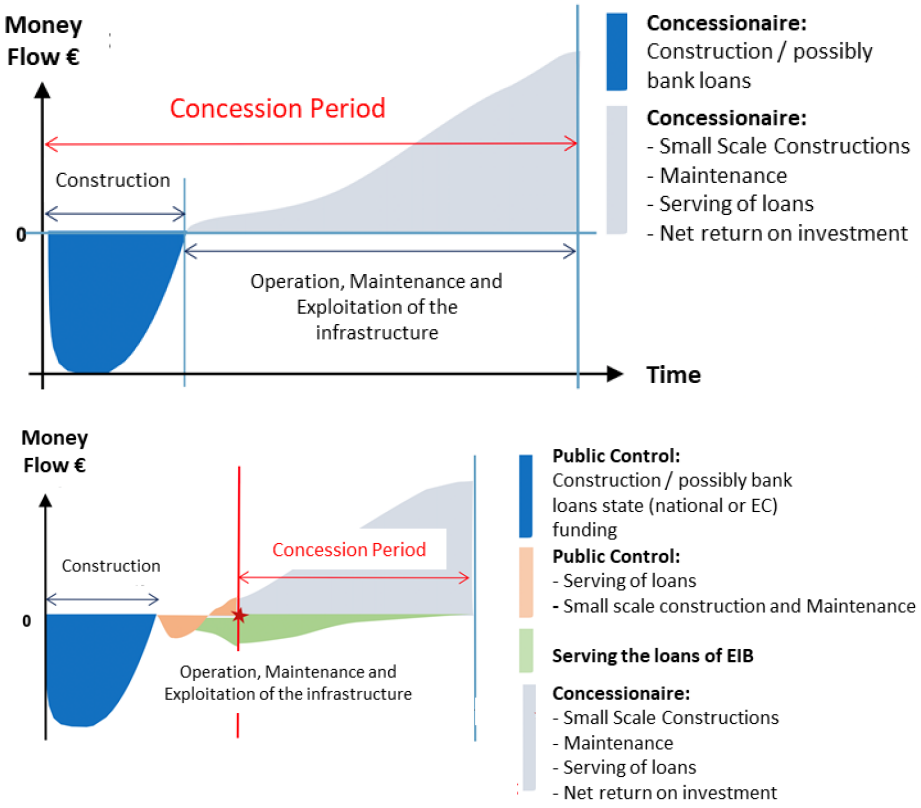
On 16/11/2017, HRADF proceeded with the "Invitation to submit an expression of interest for the award of a service concession agreement in relation to financing, operation, maintenance and exploitation of Egnatia Odos and its three vertical road axes". In the announcement of the relevant tender procedure, the duration of the concession was set as a period of up to 40 years. On 16/2/2018, applications were received from 9 investment schemes, of which seven (7) pre-consortia were pre-selected (16/5/2018) and asked to submit binding offers. Large investment groups from abroad participated mainly in partnership with major Greek construction companies.

According to Directive 2014/23/EU, "*in order to avoid market segregation and restriction of competition*", the duration of the concession should be limited to the period in which the concessionaire can reasonably complete the amortization of its investment. Below is a typical cash flow chart of a motorway concession contract, where the concessionaire undertakes the financing and construction of the project in exchange for its exploitation for a sufficient period of time, as well as the corresponding chart for the "paradoxical-conflicting" form of the specific concession of EO.

It appears that the concession agreement intended for the specific Highway significantly differs from a standard concession contract: it concerns an infrastructure project that was already fully constructed with EU and national funds, needing very little new investment - the most important new investment being to upgrade the Chalastra-Evzonoi vertical axis with an estimated budget of no more than €290 million, which does not justify the need to seek for an investor to manage a fixed asset totaling €7 billion according to the provisions of the Directive quoted above.

As already described, the concessionaire will receive an asset with no pending issues and free of burdens. The concession coincides with the onset of high profitability from the exploitation of the highway for 35 years. In this sense, public interest could only be served by receiving a sufficient prepayment of future income in the form of a "concession fee". Moreover, this argument makes sense if the government faced an urgent need to raise future revenues in financial terms, better than those of today's public borrowing. Yet, even this is not the case anymore, since currently government lending has very low interest rates.

Figure 1. Traditional model of Concession and the special case of EO



So, the main plausible reason for proceeding with the EO concession was the pending Memorandum obligation since 2011 – Greek governments had failed to develop and submit to the "lenders" a well-documented, convincing, alternative plan proving it would have better results, as we are doing in this paper. At the same time, we must admit that construction groups, whether domestic or European, obviously exert very strong pressure to undertake such an extremely profitable asset.

Additionally, the following issues arise: Egnatia Odos was EU-funded and constructed as a development project for the regional areas of Northern Greece, which were among those with the lowest GDP p.c. in Europe. Raising tolls at the level foreseen in the draft concession contract, without this being justified by future investments to be done, offset the developmental character of the project. It was to be expected that travel would be reduced, especially among the economically weaker members of the population, after passing on the increased costs to MO users, thus giving them an incentive return to the old networks, which degraded road safety.

Assessment of the value and the actual cost of the concession is extremely important for the financial interests of the Greek state. On the other hand, it is very tricky to effectively assess the future necessary repair and maintenance burden. Candidates for the concession may overestimate artificially extensive relevant costs, in order to justify a longer duration and a lower price of the concession contract planned.

Similarly, the attempt to estimate future traffic loads and, therefore, revenue through tolls, for an extremely long period (35 years), entails an extremely high degree of uncertainty. It is a given that in the present circumstances anyone interested in the operation of EO, would present the worst possible scenario of future traffic loads as the main one.

In addition, for all the above very important issues, there is no publicity, open discussion or consultation – on the contrary, HRADF proceeds with secret pre-negotiations with the candidate concessionaires.

Finally, if we try to compare other concession highways with Egnatia Odos, which remains a public highway, we should note that (i) the cost of transit for users of other highways in Greece is currently more than double compared to that of the EO (0.065 €/km compared to 0.03 €/km); (ii) operation and maintenance costs of the public EO are significantly lower than those on highways under concession contracts (a provocatively shocking example is Attiki Odos).

5. The finance of EO operation

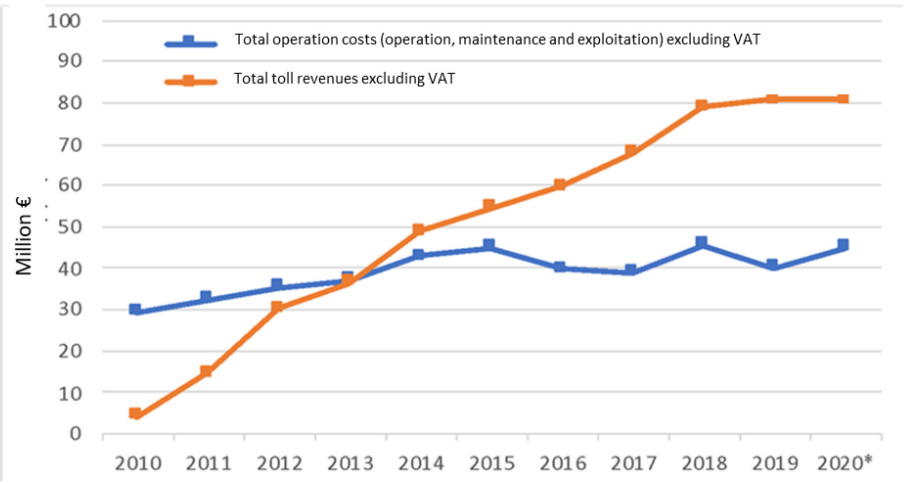
In the previous period – 2010 till 2019 – of EO annual operation, maintenance and exploitation costs and tolls ranged from 42 to 50 thousand euros per operating kilometer, excluding VAT (estimation for 2020 was 47,821€/km). Costs per kilometer were relatively stable at an average figure of 47,500 €/km, although, in the same period, operating kilometers rose/dropped from 620 up/down to 241 (due to the gradual completion of basic construction) and, in addition, heavy road maintenance works were launched in 2018.

On the other hand, the operation of toll stations started in 2010, after the completion of the construction of the entire main axis. Throughout that period, charges on EO were between 0.02 and 0.03 €/km (excluding VAT). A recent ministerial decision stabilized toll costs for users at 0.03 €/km – however, as already mentioned, the draft of the concession agreement provides for a very significant increase up to the level of the other privatized highways of the country (0.065 €/km). On an annual basis, toll revenues started from €4 million in 2010, and rose to €81 million with 16 toll stations by 2020 (estimation).

The following chart presents the annual evolution of revenues and total costs of Egnatia Highway and its Vertical Axes till 2020. After 2013, the year when 6 toll stations were in operation along 740 kilometers, toll revenues rose above the operating, maintenance and upgrading costs, despite the relatively low charge already mentioned.

Based on the above, the Financial Statements of EO may report losses in the balance sheets published but they include depreciation of the fixed asset. On the other hand, positive EBITDA since 2014, reaching €33.17 million in 2019, indicates the viability of the operation, as well as the liquidity capacity for new investments (after repayment of loans) in the medium run. Similarly, from 2013 onwards, current assets exceeded current liabilities – in fact, current assets were more than ten times higher in 2019 (€282.12 million compared to current liabilities at only€ 22.16 million).

Figure 2. EO total operation costs and toll revenues till 2020



In fact, EDITDA may also increase further since there are several Stations not yet operative, even today, and toll charges may marginally increase.

It is, therefore, strange that the concession of EO operation and maintenance is combined with the construction of the Chalastra - Evzonoi vertical road axis, tunnel upgrade projects, construction of Highway Service - Rest stops and Parking Facilities, etc., thereby essentially reducing the price requested for the concession by the state, although both funding and know-how can be easily and effectively covered by EO itself.

5.1 Detailed presentation of operation, maintenance and highway upgrading costs

Operation and basic/regular maintenance of the EO include all activities required to maintain the service provided at the optimum level: highway cleaning operations, safety barrier replacements, patrols, surveillance costs and emergency response teams, control centers, fire safety, maintenance of electromechanical equipment, road markings, local pavement restorations, instrumental monitoring of structures, geotechnical monitoring, snow removal, as well as relevant payroll costs. It is obvious

that the operating and regular maintenance costs are not fixed per kilometer, but depend on the geographical location, altitude, type, and range of the specific part of the infrastructure.

The following table presents the costs of the activities mentioned above, according to the relevant subcontracting tenders conducted by EO – overall exceeding €20 million annually (excluding VAT) – it is noteworthy that the resulting discounts are 60% on average.

Table 1. Contracts of operation and maintenance subcontracting 2015-2020

Year	Scope of the Contract	Duration	Tender budget without VAT	Average Discount	Contract price excluding VAT	Cost of operation and maintenance per year (excluding VAT)
2018	Operation & Maintenance and construction of toll stations 2018-2020: A	18 months	47,450,000 €	59.11 %	19,401,536	26.6 million €
2018	Operation & Maintenance and construction of toll stations 2018-2020: B	18 months	49,455,000 €	58.21 %	20,668,683	
2015	Operation & Maintenance 2015-2018 (1)	3 years	60,483,871 €	55.30 %	27,488,723	18.3 million €
2015	Operation & Maintenance 2015-2018 (2)	3 years	60,483,871 €	55.18 %	27,485,291	

Another important category of costs results from electric lighting at crossroads and transport junctions, tunnels, frequently foggy sections of roads, etc. With respect to this, it is important to mention the possibility of heavy reduction of such costs by replacing bulbs with new, lower energy consumption lighting (LEDs). (The specific project could be financed by respective surpluses within 7 years.

Moving on, we also need to consider costs for the operation of frontal and lateral toll stations including electronic toll collection systems – personnel's wage costs, systems maintenance costs, civil engineering and electromechanical works, and electronic systems are the relevant expenses. Nevertheless, in this category, we also have to consider that relevant costs can be substantially reduced if we assume the conversion of the toll system into a 'free flow' system.

Next to the operational costs (including regular maintenance) we have to take into account those for heavy maintenance and new construction. The first includes the replacement of asphalt layers, long-term maintenance scheduled or structural reinforcement of motorway structures (bridges, tunnels, support systems), replacement of safety barriers and vehicle interception systems due to aging or changes of specifications, replacement of vertical signs and support bodies, restoration of embankments, repairs to culverts and other hydraulic works, inspections and repairs of damage to underground works, costs scheduled for replacing or modernizing electro-mechanical installations, restoration of existing landslides and new slope failures, etc., plus replacement of metal safety barriers with new vehicle interception systems.

The largest share of heavy maintenance expenditure concerns the restoration of road pavements. If we calculate this based on current costs and historical data from the respective EO subcontracting contracts in recent years, it comes, on average, up to 190 thousand €/km excluding VAT (related discount rates reached 61%). The frequency of road remediation operations is based on the load of heavy vehicles. We estimated that the frequency of restoration has to be between 5 and 10 years and, in parts of heavy truck traffic load, located mostly in the Prefecture of Thessaloniki, at 5 years[8].

On the other hand, there are also new construction works scheduled within the next 5 years. These refer to new or upgraded existing motorway segments, construction of new toll stations, Highway Service - Rest and Parking Facilities, installation of a hybrid analog tolling system in urban areas, upgrading tunnel systems, and reinforcement of structures and restoration of embankment stability. Of these, the most important expenditure concerns the upgrading of a 45 km motorway section along the Chalastra – Evzonoi axis. In our estimate, we consider that the execution of these new construction projects will be assigned through public tenders and the calculations were made based on data from previous similar projects realized by EO, taking into account average past discounts.

Finally, we have to consider other expenses, including management staff costs and various administrative expenses, such as project insurance and support for emergency reasons (Traffic Police, Fire Department, etc.).

Based on the assumptions and analysis above, the estimated total annual costs for the operation, maintenance and upgrade of Egnatia Odos and its vertical axes during the 35-year period (2022-2056) ranges from €56 million to €118 million. In the first years, total expenses will be higher, as construction of new segments is to be expected, while, at the same time period, heavy maintenance works will also be taking place. The average annual cost of operation, maintenance, and upgrade comes to €74 million.

8. Obviously, the forecast of heavy maintenance entails significant uncertainties and risks, which, in the frame of the extremely long-term forecasts for the 35-year concession intended have been exacerbated: during the period of the concession tender, according to information leaked to the press (the unacceptable secrecy of relevant negotiations should be noted here), heavy maintenance costs vary from €1 to €6 billion!

5.2 Analysis of future toll revenues

Revenues from the operation of EO and its vertical axes come almost exclusively from charges for using the specific infrastructure. Tolls yield up to 98% of total revenues[9] – therefore, it is important to discuss in detail the billing assumptions and scenarios, as we do below.

According to the most recent Joint Ministerial Decision, toll charging (including VAT) for the basic category of vehicles using the EO will come to 0.04 €/km in 2021 before the concession; after it, charges will rise again to 0.05 €/km with the commencement of the concession contract (assumed to be in the beginning of 2022) reaching 0.064 €/km by 2024, similar to the rest of the concession contracts concerning other highways of the country. This increase of toll charges projected was made solely to make the intended concession even more attractive.

Below we examine whether holding toll charges at the current level of 0.003 €/km is economically viable, compared to three other alternative scenarios: (i) 0.04 €/km for 35 years; (ii) starting with 0.04 €/km and then, after the 2nd year rising to 0.05 €/km, and (iii) based on the ministerial schedule mentioned above charging up to 0.064 €/km. The basic scenario and the one with an average charge of 0.04 €/km are compatible with the case where the present status will not change, and the concession intended will not proceed.

Analyzing the time series resulting from the specific scenarios provides us with the following conclusions:

i. At the existing low charge of 0.03 €/km, annual toll revenues range from €106 to €178 million, while when the average toll rate is raised to 0.04 €/km, annual revenues range from €134 to €224 million. The other two scenarios, at 0.05 €/km in 2022 and 0.064 €/km by 2024, provide annual revenues ranging from €149 to €250 million and from €149 to €278 million, respectively.
ii. Therefore, cumulative revenues for the 35-year period come to €4.99 billion for the basic, existing charge and rise to €6.28 billion for a modest increase to 0.04 €/km, while in the other two scenarios it rises to €7.01 and €7.78 billion, respectively.

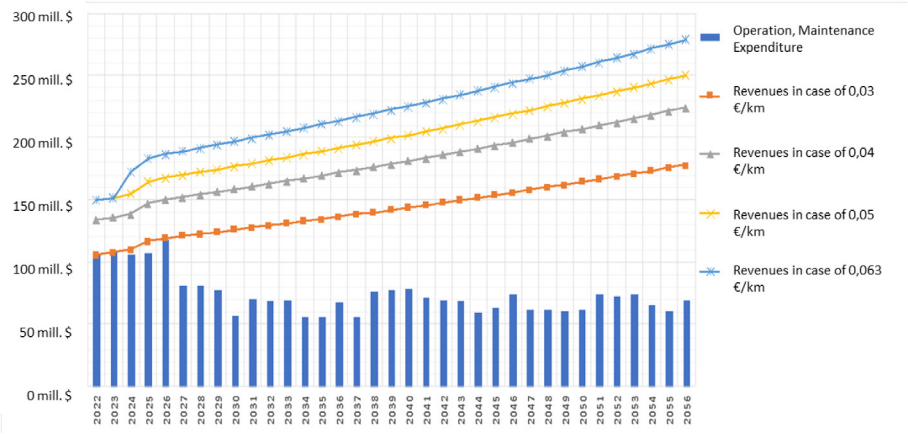
6. Forecasting future results of EO operation and exploitation

Detailed data of costs and revenues were presented separately in the previous paragraphs. The following figure depicts the time series of annual total expenditure and revenues. It is obvious that, when maintaining the current low charge of 0.03 €/

9. Other sources of income are the Rest and Service Stations, the leasing of premises for installing the mobile telephone network, as well as that of energy or telecommunication networks. Furthermore, the compensation of the road administrator due to damage of third-party liability (accidents), as well as the imposition of fines for non-payment of tolls.

km, revenues are slightly above expenditure during the first 5 years, during which execution of new construction and heavy maintenance works is expected to take place. For the rest of the 35-year period, exploitation of EO is to be consistently profitable. As expected, profitability is even higher in the other three scenarios with increased toll charges and, consequently, higher total revenues.

Figure 3. Annual total operation and maintenance expenditure vs total revenues for a period of 35 years (excluding VAT)



In other words, losses do not appear in any of the studied cases. Even in the first five years of the low charges scenario, financial results are marginally above zero. More specifically:

i. In the case of 0.03 €/km tolls, annual profits range from €0 to €114 million. Cumulative financial result over the entire 35-year period is estimated at €2.4 billion.
ii. In the case of 0.04 €/km tolls, annual profits range from €27 to €160 million. Cumulative financial result over the entire 35-year period is estimated at €3,7 billion.
iii. In the case of 0.05 €/km tolls, annual profits range from €42 to €185 million. Cumulative financial result over the entire 35-year period is estimated at €4.4 billion.
iv. In the case of 0.063 €/km tolls, annual profits range from €42 to €213 million. Cumulative financial result over the entire 35-year period is estimated at €5.2 billion.

According to the relevant European Directive, it is important and interesting to calculate the break-even point of toll charging (defined as the amount to be paid by a road user so that total operating, maintenance and upgrading costs can be covered) for the EO case, something that, unjustifiably, has not been done by the Greek State for any

of the national public roads. It turns out that, for the entire 35 years, the break-even charge for the basic category of vehicles (category 2) is 0.0125 €/km (VAT excluded). Any additional charge contributes to the profitability of the highway operation.

Based on all the previous calculations we end up with the following table that compares the financial results of the two alternative management models for the EO and the Vertical Axes: the 1st model reflects the situation when EO retains management and toll collection, while works and services are undertaken through public (sub-) contracts with private entities (the scheme currently operating), the 2nd is the case of moving on with the concession, in which toll collection and undertaking of works and services are to be managed by the concessionaire.

Starting from the intention to ensure sufficient comfort and the highest safety for users, as well as to combine socially acceptable operating costs (tolls) with attaining significant public financial benefits, the choice of a concession contract for an already constructed infrastructure project and for a long period of 35 years is extremely problematic: on the one hand, it multiplies costs for users and, on the other hand, it deprives the State of almost all future financial benefits since it will be receiving only a subset of them.

Sustaining the management under the control of EO with the present model of subcontracting can bring a total profit to the State between €3 billion and €6.15 billion, depending on the toll charge scenario. In this case, it is possible to keep toll charges at lower levels and generate significant profits for the State, at the same time. Instead, in this concession model, given the assumptions made according to the information leaked, notwithstanding the secret negotiation practice unacceptable for public interest purposes, total public financial benefits can be estimated between €1.23 billion and €1.98 billion. When a higher IRR or less favorable assumptions of revenue and expenditure are applied, total profits are significantly limited.

According to low toll scenarios (0.03 €/km or 0.04 €/km), EO will even return/ reinvest €85-125million per year. If we consider the high toll charge scenarios (0.05 €/km and 0.063 €/km), this reinvestment may rise to €150–175 million per year, with the Concessionaire returning only €15–17 million (7.5% of revenue) per year to the State! This is, actually, the main message from the economic comparison of the two alternative management models: if the present status is sustained and depends on the amount of tolls, the State will have annual profits of up to €175 million for 35 years, while in the case of concession, this will dramatically drop to €17 million!

Table 2. Comparison of public (financial) benefits in the two alternative cases of EO management

		1st model: EO controls EO (total annual average costs: 74 million €/km)	2nd model: Concession Contract	
			2.a: total annual average costs remain the same (74 million €/km)	2.b: increased total annual average costs: 110 million €/km
Low Tolls scenario: 0.03€/km	**Total Public Financial Benefit for 35 years**	**€2,996,259,328**	-	-
Medium Tolls scenario: 0.04 €/km	**Total Public Financial Benefit for 35 years**	**€4,450,603,127**	-	-
Tolls 0.05 €/km as the minimum charge stipulated in the framework of the concession intended	Public financial contribution (lump sum)	-	€-60,000,000	€-60,000,000
	Annual revenues – total in 35 years	€5,268,671,514	€529,283,240	€529,283,240
	Concession fee at the starting point commencement (lump sum) – IRR estimate ~8%	-	€1,200,000,000	€760,000,000
	Total Public Financial Benefit for 35 years	**€5,268,671,514**	**€1,669,283,240**	**€1,229,283,240**
Tolls 0.0633 €/km as the minimum charge stipulated in the framework of	Public financial contribution (lump sum)	-	€-60,000,000	€-60,000,000
	Annual revenues – total at 35 years	€6,153,930,193	€589,623,531	€589,623,531
the concession intended	Concession fee at the starting point (lump sum) – IRR estimate ~8%		€1,450,000,000	€920,000,000
	Total Public Financial Benefit in 35 years	**€6,153,930,193**	**€1,979,623,531**	**€1,449,623,531**

12. Conclusions

Essentially, the specific concession model only concerns the capitalization of future revenues, i.e., instead of providing €6 billion for ~~the~~ public finance over 35 years, in the best case it will generate no more than a concession fee of €1.5 billion in its commencement (lump sum). In fact, it is considered extremely likely that the concession fee will be much lower, rendering the already problematic concession model into one that is also provocative and scandalous.

In this sense, the concession contract of the fully constructed Egnatia Highway is not a productive investment and will not bring additional benefits. It is, rather, a form of merely privatizing the toll collection procedure, instead of assigning it to a public interest company (EO). Data shows that for the management of EO, including new upcoming construction works, there are no financing/investment needs that justify the necessity for private capital investment through a 'formal' concession contract in accordance with the definitions and provisions of Directive 2014/23/EU (incorporated into national law 4413/2016).

It should also be noted that the construction companies participating in the consortia that expressed their interest for the specific concession also carry out public projects entrusted by the State following public tenders. In these projects the discounts offered by such companies currently amount to almost 50%. As we have already mentioned, in the case of these companies gaining control through the concession, the way is opened for additional profitability if worse conditions are maintained in the technical works they, directly or indirectly, implement.

The best result, by far, for the economy and society is achieved by maintaining the present mixed management model, according to which heavy maintenance and extension projects are undertaken by private construction companies subcontracted by the state. EO and the tolls are publicly controlled. Thereby, besides execution of other public works along EO crossing areas and financing wider projects in the Regions of Northern Greece, according to relevant government infrastructure planning, contribution towards reducing ~~X~~the national debt will also remain significant since depositing a percentage of profits into the Public Debt Servicing Account will continue the repayment of EIB loans for the Ministry of Finance as well.

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DOES INNOVATION LEAD TO GROWTH? AN SDG FOR COMPANIES IN THE BLACK SEA MARKETS BEFORE AND AFTER COVID-19

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Abstract
Based on the agenda 2030 for a healthier, safer and more prosperous world, were 17 sustainable development goals (SDGs) were proposed pertinent to economic, social and environmental aspects. One of these goals, namely number 8, is about "promoting sustained, inclusive and sustainable economic growth". One of the factors promoting economic growth is innovation for the economy as a whole and for individual corporations. During the last decades, the economy in most of the developed countries has been transformed from a production to a knowledge economy. Expenditure for research and development (R&D) and company intangible assets serve as a proxy for innovation for the companies considered. Therefore, the existence of intangible assets in a company indicates that it pursues a level of innovation; furthermore, the higher the innovation, the more competitive advantages for the company and the higher its potential for survival and growth in future globalized markets. Our objective in this paper is to examine the research question, i.e., whether the existence of more innovation proxied by intangible assets or/and by R&D investment undertaken by a company leads to increasing market value, better performance, and future growth in the years before and after the COVID-19 pandemic. This study focuses on companies of Black Sea countries: Bulgaria, Georgia, Romania, Russia, Turkey, and Ukraine. From a preliminary examination of data obtained from the Thomson EIKON database, we found that research and development expenses are not reported in the case of most Bulgarian and Russian companies and only very few of Romanian and Turkish companies prepare such reports, while there are no data at all for the listed companies of the Georgian and Ukrainian markets. Hence, we limit our investigation to the three out of the six markets, specifically to the Balkan area countries, i.e., the companies listed in the stock markets of Bulgaria, Romania, and Turkey. For the examination of testable hypotheses, we use correlation and regression analysis. Results will shed more light on this issue and will help practitioners plan their strategy, accordingly; moreover, scholars will learn more about this intricate relationship, especially in the framework of developing economies.

JEL Classification: G30, G39
Keywords: R&D Investment, Firm Performance, Value, Growth

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1. Introduction

Based on the agenda 2030 for a healthier, 17 sustainable development goals (SDGs) with economic, social, and environmental aspects for a safer and more prosperous world, were proposed. One of these goals, namely, number 8, is about "promoting sustained, inclusive and sustainable economic growth". One of the factors promoting economic growth is innovation for the economy, as a whole, and for individual corporations.

During the last decades, the economy in most of the developed countries has been transformed from a production to a knowledge economy. Griliches (1984), Sher and Yang (2005) and Cho and Pucik (2005) that have undertaken some of the studies using expenditure in research and development (R&D) and the intangible assets as a proxy for innovation for the companies studied. Intangible assets are immaterial assets not reported in balance sheet in the past, which are now reported and provide knowledge and information and inspire creativity and inventions comprising the intellectual or knowledge capital of the company.

Idris (2003) stated that intellectual property assets are a "power tool" for economic growth not yet exploited to its maximum limit. There are several definitions for intellectual property or intellectual capital in pertinent literature [Sitar and Vasic (2004)]. In general, the two terms are used interchangeably. Therefore, the existence of intangible assets in a company indicates that it pursues a level of innovation. Hence, the higher the innovation of a company, the more its competitive advantages and the higher its potential for survival and growth in future globalized markets. As firms use and exploit their knowledge resources and their intellectual capital, they build strong competitive advantages (Stewart, 1997; Teece *et al.* 1997; Teece, 2006).

Mauboussin and Kawaja (1999) found that the value of a company is the present value of all future free cash flows it will generate. Therefore, if a company has more innovation, this implies that it has more intangible assets and R&D investment (expenditure), which should bring higher company value and higher future cash flows.

Our objective in this paper is to examine the research question, i.e., whether the existence of more innovation proxied by intangible assets or/and by R&D investment in a company leads to increasing market value, better performance, and future growth in the years before and after the COVID-19 pandemic. This study focuses on companies of Black Sea countries, namely: Bulgaria, Georgia, Romania, Russia, Turkey, and Ukraine. From a preliminary examination of data which is from the Thomson EIKON database, we found that research and development expenses are not reported by most Bulgarian and Russian companies and are reported by very few Romanian and Turkish ones; furthermore, there are no data at all for companies listed in the Georgian and Ukrainian markets. Hence, we limit our investigation to the three out of the six markets, specifically to the Balkan Black Sea countries, i.e., companies listed in the stock markets of Bulgaria, Romania, and Turkey. For the

examination of the testable hypotheses, we use correlation and regression analyses. Results will shed more light on this issue and will help managers of these companies interested in innovation to plan their strategies accordingly and scholars to learn more about this intricate relationship, especially in the framework of developing economies.

The rest of the study is organized as follows: the next section briefly presents some pertinent tax and accounting laws and the relevant literature review. The third section contains the data, the methodology and the testable hypotheses. The fourth section depicts and analyses our empirical results, and the final section contains a summary and offers future research ideas.

2. Tax and Accounting Laws Regarding R&D Expenditure Literature Review

The concept of research and development (R&D) contains the various activities a company is involved realized so as to a) create new products, processes or services products comprise formulas, inventions, pilot models, computer software and techniques; b) discover solutions for problems and/or c) improve existing products or services [OECD (2002)]. Intangible assets can be defined as business assets that have no physical form and are distinguished in two types: those purchased and those internally generated. If a company has its own R&D department, it incurs relevant expenses and, if research results concerning specific products/solutions lead to intellectual property or intellectual capital, such as patents or copyrights, etc., future probable economic benefits will be created for the enterprise. There are national and international laws stipulating different accounting for R&D expenses and intangibles, such as the International Financial Reporting Standards (IFRS) and the US-GAAP. Purchased intangibles are treated similarly to tangible assets, whereby the purchase price is capitalized. On the other hand, internally generated intangibles are treated differently from country to country. R&D expenditure in some countries is treated similar to intangible assets generated internally. There are national laws on the accounting of R&D expenses as well as the international Financial Reporting Standards (IFRS) and the US-GAAP.

There is a wealth of literature concerning innovation as expressed by investment in R&D and by intangible assets related to firm value and firm performance. Most studies have revealed a positive correlation between innovation and performance. However, some researchers found that there is no linear relationship between the variables mentioned above and some studies have indicated a negative relationship.

We examine this relation as early as 1984, when Grilishes and Mairesse (1984), using a sample of 133 large U.S. firms for the period 1966 to 1977, analyzed the relationship between output, employment, and physical and R&D capital. They found a strong positive relationship between firm productivity and the level of its R&D investment. Johnson and Pazderka (1993), studying a sample of Canadian

companies listed in Toronto stock exchange, showed a positive, statistically significant relationship between R&D expenditure and firm market value. These results implied that "investment in R&D is a rational allocation of resources".

Mairesse and Hall (1996) compared the contribution of R&D expenses to a firm's productivity for the French and US manufacturing companies in the 1980s and found that the contribution of R&D expenses to sales productivity growth declined during the 1980s, and this decline was higher for US firms than for French ones. Lev and Sougiannis (1996) found a positive relation between US company R&D capital and stock returns. This implied that either R&D-intensive firms were systematically mispriced by the market, or investors required compensation for the extra-market risk associated with R&D investment. Later, Ho, Keh, and Ong (2005), studying a sample of USA companies, examined the relationship between firm performance and the intensity of their investment in R&D and advertising expenses for 40 years from 1962 to 2001. These researchers found that investment in R&D had a positive effect on the one-year stock market performance for manufacturing companies but not for non-manufacturing ones. Lin and Chen (2005), focusing on 78 US technology companies, found that large firms have more advantages for technological innovation due to better exploitation of synergy effects of their technology portfolios, compared to smaller companies. Warusawitharana (2015), investigating a sample of non-financial USA companies, found that R&D expenditure had an economically and statistically significant impact on profits and firm value. VanderPal (2015) investigated the R&D impact on company value for a sample of 103 US listed companies for the 1979 to 2013 period. His results indicated a positive relationship between R&D expenses and equity; he also found a positive relationship between revenue and ~~the~~ ROA and a negative relationship between revenue and ROE.

Abrahams and Sidhu (1998), studying a sample of Australian companies, indicated that capitalized R&D on balance sheets had a significant positive information effect on firms' value (stock prices).

In Asia, Sher and Yang (2005), looking into the Taiwanese integrated circuit (IC) industry, found that higher R&D intensity and higher R&D manpower were positively related to firm performance, as measured by the return-on-assets ratio (ROA). Zhu and Huang (2012), focusing on the Chinese listed information technology (IT) companies, found that R&D expenditure had a positive effect on the firm's performance, but lagged for one year. Ghaffar and Khan (2014), investigating the pharmaceutical industry companies of Pakistan, found the relationship between research and development and firm performance to be positive. Jaisinghani (2016), reporting on a sample of Indian companies in the pharmaceutical sector for the period 2005-2014, found that there was a positive relationship between R&D intensity and performance, with performance being proxied by two measures of profitability, namely, the ratios return-on-assets and return-on-sales. Wang *et al.* (2017) found that R&D investments create additional value for

companies under study when there are interactions with IT investment in several industry sectors for China. Chen *et al*. (2019) examined this matter in relation to Taiwanese semiconductor industry companies and found that R&D investment had a positive and one-year lagged effect on companies' performance. Firm size was also significant in that it positively affected business performance. More recently, Tung *et al*. (2021), studying listed companies of the developing economy of Vietnam for the 2010-2018 period, found that R&D expenditure/investment had positive effects on revenues, profits, return on assets (ROA) and return on equity (ROE). In addition, their results suggested that companies with high R&D investment outperform those with low R&D, in terms of profit, revenue and ROA.

In Europe, Greenhalgh and Rogers (2006) found that companies filing for patents with the European patent office had, on average, higher R&D expenditure and this led to higher company value compared to cases filed with the UK patent office. Harhoff (2006) found that, since the early 1980s, patent rights as a type of innovation have become important resources for companies to build and maintain their value. Beld (2014), looking into a sample of publicly listed firms in Belgium, Luxembourg, and the Netherlands, found that return on assets (ROA) was positively affected by research and development (R&D) expenditure. Regarding the European markets, Almeida *et al*. (2019), based on the EU Industrial R&D Investment Scoreboard for the 2003–2013 period, found that R&D investment positively influenced a firm's performance measured by sales and operating profit. Dimitropoulos (2020) examined the impact of intangibles on financial performance by examining the impact of R&D investment on the profitability of Greek firms, especially during the sovereign debt crisis for the 2003-2016 period. He used panel regression analysis and results indicated that R&D investment and expenses negatively affected sample firmprofitability before the crisis, while, during the crisis from 2011 to 2016, the companies that managed to sustain or increase their R&D investments improved their profitability. This finding is important because it indicated that during a period of scarcity of external financing and financial uncertainty, R&D investment could be a vital tool for the sustainability and growth of companies.

Regarding the market of Turkey, Bouaziz (2016), studying the BIST technology index companies in Istanbul Stock Exchange, examined the impact of R&D expenses on firm performance for the 2010-2014 period. The author employed the/a pooled regression model and the/a cross-sectional time series analysis technique and concluded that there is no correlation between R&D expenses and firm performance. Yildirim (2020), looking into a sample of 138 companies listed in the Istanbul Stock Exchange during the 2007 to 2018 period, examined the impact of R&D investment on firm value in different groups of firms. These groups were classified according to their R&D investment level, company size and risk. His results revealed that R&D investment had a positive effect on firm value. However, the effect of R&D investment was significant and positive in the group of companies

of a high R&D investment level, while for the group of companies with a low level of R&D investment there was no meaningful relationship. In terms of size, results showed that the impact of R&D investment on firm value for small firms was positive, while it was negative for large firms. In terms of riskiness for the subsample of low-risk companies, R&D investment affected firm value positively, while for high-risk companies there was no significant effect on firm value.

Regarding the market of Romania, Diaconu (2018) showed that the main weaknesses in business innovation in Romania over time consisted of the extremely low share of innovative firms, a low level of business innovation expenditure and high volatility of innovation performance based on creative effort resulting from R&D activities still concentrated in a few industries.

Fábio de Oliveira and Ferreira da Silva (2018) investigated whether internal and external R&D expenses had any impact on innovation development and whether the latter had any effect on the financial performance of a sample of European manufacturing firms. Among the countries selected were Bulgaria and Romania, forming one group out of the seven examined. The authors' results indicated that R&D that affected innovation performance did not influence financial performance for the Balkan countries of Bulgaria and Romania, while it had a positive impact on financial performance for Portugal and Spain (group 3), as well as for Estonia and Lithuania (group 4).

Regarding the market of Bulgaria, Georgieva (2019) indicated that, when national accounting standards are applied, Bulgarian innovative enterprises do not publish any R&D information. She revealed that Bulgarian enterprises do not develop high technological innovations but mainly focus on developing incremental products and processes. So, under the current global technological development, if innovative enterprises do not disclose mandatory R&D information, the accuracy of the data reported in their financial statements might be questioned. This cannot be interpreted as a good and positive sign by investors and could lead to bigger lack of investment, which, as noted, is an essential part of budgets for research and development by Bulgarian companies.

Therefore, since there are few studies on Bulgaria and Romania regarding this issue and a few more for Turkey, this study that examines these three markets will shed more light on the matter.

3. Data, Testable Hypotheses and Methodology

3.1 Data and Variables

This study focuses on firms in the three Black Sea countries of the Balkan peninsula. Turkey is a growing emerging economy, while Bulgaria and Romania are former communistic economies or transition economies and, therefore, moderate or modest innovators in Europe and globally.

Our sample comprises all companies listed in the stock markets of Turkey (the Borsa Istanbul in Istanbul), Bulgaria (the Bulgarian Stock Exchange in Sofia), and Romania (the Bucharest Stock Exchange (BVB) in Bucharest). The initial sample consisted of 398 firms in Turkey, 261 firms in Bulgaria and 354 firms in Romania; in other words, there were a total of 1013 companies in the initial sample. All data were collected from the Thomson EIKON database. The period examined extends from 2000 to 2020. The year 2020 is the year of the global health crisis of the COVID-19 pandemic, which has caused a severe negative economic impact to all markets and companies around the world. Therefore, we tested our hypotheses three times. Once for the entire time period; the second time we excluded the year 2020, in order to avoid contamination of our results by this crisis. Hence, we examined the same hypotheses for two subperiods: the first one from 2000 to 2019 (before the COVID-19 crisis) and for the year 2020 (the COVID-19 year). We did not have the necessary financial statement information for all the years for all the companies, so some cases/companies with missing data were excluded. The final sample consists of 377 Turkish firms, 221 Bulgarian firms and 147 Romanian firms. Hence, there were a total of 746 firms in the final sample.

We used the market value of equity as a proxy for firm value based on Warusawitharana (2015); the R&D expenses following VanderPal (2015) and Dimitropoulos (2020) and the ratio of R&D divided by sales for size adjustment according to Ho *et al*. (2005) and Jaisinghani (2016) as the first proxy for firm innovation investment; intangible assets and the ratio of intangible assets divided by total assets as the second proxy for firm innovation investment according to Bolek and Lyroudi (2017); return on assets (ROA) and return on equity (ROE) as the two proxies for company performance according to VanderPal (2015). Finally, as a control variable, we used company size as measured by the logarithm of total assets, following Richard *et al*. (1991) and Kumar and Warne (2009), since size is commonly used in empirical corporate finance research testing for a "size effect" [Rajan and Zingales (1995); Frank and Goyal (2003); Moeller, Schlingemann, and Stulz (2004); Klapper and Love (2004); Shubita and Alsawalhah (2012); Vijh and Yang (2013); Dang *et al*. (2013); Gabaix, Landier, and Sauvagnat (2014)]. Hence, we also tried to test for a "size effect". Based on Asimakopoulos *et al*. (2009) and Lee (2009) and others, larger companies perform better because they have access to more financial resources, incur lower financial costs and make better bargain deals, being able to take advantage of scale economies.

Regarding the profitability ratios that measure company performance, we follow the terms/stipulations of Jose *et al*. (1996), since we have companies from different countries and different taxation systems. Therefore, instead of earnings after taxes in the numerator for both ratios as is the classical approach, we use the ratio of earnings before interest and taxes (EBIT) to total assets for ROA and the ratio of earnings before taxes (EBT) to equity capital for ROE.

3.2 Testable Hypotheses

Based on the relevant literature discussed above in order to achieve our objectives, we test the following hypotheses:

Some researchers, such as Sougiannis (1994), Abrahams and Sidhu (1998), Toivanen *et al*. (2002), Greenhalgh and Rogers (2006), Pindado *et al*. (2010), Duqi *et al*. (2011) and Wang *et al*. (2017) highlight that R&D expenditure or investment enhances corporate value. Hence, we have formulated our first testable hypothesis:
H1: *R&D expenditure and intangible assets as proxies of innovation in a company are expected to increase the value of the company studied.*

Based on Sher and Yang (2005), Beld (2014), Warusawitharana (2015), VanderPal (2015) and Jaisinghani (2016), who found that R&D expenses were positively related to firm performance as measured by return on assets (ROA), we have formulated our second testable hypothesis:
H2: *R&D expenditure and intangible assets as proxies of innovation in a company are expected to increase the performance of the company studied, as measured by the ROA and ROE indicators.*

Lin and Chen (2005), focusing on US technology companies, found a size effect, since large firms had more advantages for technological innovation compared to smaller ones. Pindado *et al*. (2010) reported a positive relationship between size and market response to R&D investment. Schimke and Brenner (2014), looking into 1000 European companies, found that the positive effect of R&D activities on turnover growth strongly depended on firm size and industry sector. The same result was found by Chen *et al*. (2019) for Taiwanese semiconductor companies, since the larger the company, the greater its exposure to R&D and the more innovative the products and services it produced. This can lead to gaining a wider market share and more firm growth. In this aspect regarding innovation, the size variability should be considered. Hence, based on these studies, we have formulated our third testable hypothesis:
H3: *The size of a company is expected to positively affect innovation impact (resulting from R&D expenses and Intangible assets) on firm value and performance.*

Fábio de Oliveira and Ferreira da Silva (2018) investigated whether internal and external R&D had any impact on innovation development and whether the latter had any effect on the financial performance of a sample of European manufacturing firms. They found that the impact of innovation on financial performance was different for different groups of European companies. Banerjee and Gupta (2021), focusing on 42 countries in the 1981–2013 period, examined the extent to which firm, industry and country-level factors could explain firm-level R&D expenditure. They found that firm and industry-level determinants had higher explanatory power than country-level determinants. Thus, since in some cases, the country factor is significant and in some others not for the R&D relation to performance, it is interesting to investigate this for our sample companies; therefore, we formed our fourth hypothesis:

H4: *The country of a company is expected to significantly affect the innovation impact (resulting from R&D expenses and Intangible assets) on firm value and performance.*

3.3 Methodology

To investigate our testable hypotheses, we apply correlation analysis with the Pearson correlation coefficient and regression analysis, using the following models cross-sectionally for all the years as a whole:

$$\text{Value of firm}_{it} = a_1 + b_1\,\text{RD}_{it} + b_2\,\text{Size}_{it} + b_3\,\text{Country}_{it} + e_{it} \quad (1)$$

$$\text{Value of firm}_{it} = a_1 + \gamma_1\,\text{Intangibles}_{it} + \gamma_2\,\text{Size}_{it} + \gamma_3\,\text{Country}_{it} + e_{it} \quad (2)$$

$$\text{Performance of firm}_{it} = a_1 + b_1\text{RD}_{it} + b_2\,\text{Size}_{it} + b_3\,\text{Country}_{it} + e_{it} \quad (3)$$

$$\text{Performance of firm}_{it} = a_1 + \gamma_1\text{Intangibles}_{it} + \gamma_2\,\text{Size}_{t} + \gamma_3\,\text{Country}_{it} + e_{it} \quad (4)$$

Models 3 and 4 that examine the effect of explanatory variables on company performance are run twice, one whereby the performance is proxied by return on assets, (ROA) and the other whereby the performance is proxied by return on equity (ROE).

The four models above are run three times each for three different time periods as we have specified in the paragraphs above.

4. Empirical Results

Table 1 presents the descriptive statistics of our variables for the entire period examined. Table 2 depicts the Pearson correlation coefficients between our selected variables for the entire period examined.

Based on the Pearson correlation coefficients in Table 2, the R&D and Intangibles variables are positively correlated to market value. Neither R&D nor Intangibles are correlated to return on assets (ROA) or return on equity (ROE). On the other hand, the variables of size and country are significantly related to R&D expenses, the market value of the company, its intangible assets, and ROA. For more in-depth analysis, we perform regression analysis to investigate the explanatory power of independent variables and test our hypotheses.

Table 1. Descriptive Statistics (for the entire period)

	Minimum	Maximum	Mean		Std. Deviation
			Statistic	Std. Error	Statistic
MV	,000000	235672499999,999	896407541,910	44084213,406	4814876092,99
R&D	-1578460	615484000	10721942,99	844820,914	37210501,340
RDS	-,03	,63	,0129	,00094	,04142
Intangibles	-54438000	27675815000	134707120,52	13123528,235	1088145477,00
INTANGTA	-7,26	166,61	,1267	,02570	2,09914
ROA	-411,81	3243,65	1,6549	,36067	38,57780
ROE	109,00	212,55	,0528	,02856	3,11841
Size	5,94	26,75	17,5437	0,02314	2,48845

Table 2. Pearson Correlation Coefficients (for the entire period)

	MV	R & D	RDS	Intangibles	INTANGA	ROA	ROE	country	Size
MV	1	,550**	-,044	,265**	,011	-,005	,006	,081**	,283**
		,000	,051	,000	,355	,576	,513	,000	,000
R&D	,550**	1	-,004	,306**	-,006	-,010	,017	-,389**	,399**
	,000		,869	,000	,844	,675	,465	,000	,000
RDS	-,044	-,004	1	-,045	,386**	,027	,009	,024	-,297**
	,051	,869		,150	,000	,234	,697	,288	,000
Intangibles	,265**	,306**	-,045	1	,060**	-,003	,003	,119**	,244**
	,000	,000	,150		,000	,823	,778	,000	,000
INTANGA	,011	-,006	,386**	,060**	1	,013	-,001	,059**	-,044**
	,355	,844	,000	,000		,291	,966	,000	,000
ROA	-,005	-,010	,027	-,003	,013	1	,005	,039**	-,112**
	,576	,675	,234	,823	,291		,569	,000	,000
ROE	,006	,017	,009	,003	-,001	,005	1	,022*	,022*
	,513	,465	,697	,778	,966	,569		,015	,018

count	,081**	-,389**	,024	,119**	,059**	,039**	,022*	1	,170**
	,000	,000	,288	,000	,000	,000	,015		,000
Size	,283**	,399**	-,297**	,244**	-,044**	-,112**	,022*	,170**	1
	,000	,000	,000	,000	,000	,000	,018	,000	

Source: Authors' results based on ~~the~~ statistical analysis.
** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

4.1 Effect of Innovation (resulting from R&D and Intangibles) on Firm Value

In Table 3 we reported only the empirical results of the OLS regression analyses of the models that had the best explanatory power regarding the influence of the R&D expenses variable, in two forms, namely, as (R&D) and as a ratio of R&D to sales (RDS). We also reported the influence of intangible assets, along with the other explanatory variables, namely (size) and (country), on the company's market value (MV). We checked for autocorrelation and, in all models reported, there was positive autocorrelation since the Durbin and Watson (DW) statistic is less than 2.

Regarding the independent variable R&D expenses for the entire period examined, results in Table 3, model 1 indicate that the coefficient of the explanatory variable (R&D) is statistically significant and positive. This implies that R&D expenditure significantly and positively affects the market value of sample firms. This result is consistent with our first hypothesis and the studies of Johnson and Pazderka (1993), Abrahams and Sidhu (1998), Ho, Keh and Ong (2005), Harhoff (2006) and VanderPal (2015). Model 2 depicts the effect of R&D expenses-to-sales ratio (RDS) on firm value and this is similar to model 1. However, the coefficient of the R&D variable as an explanatory variable, versus the R&D ratio (RDS), has stronger significance (t-value), while in model 2 Size is the best explanatory variable.

Regarding the independent variable (intangible assets) for the entire period examined, results in Table 3, model 3, indicate that the coefficient of the explanatory variable (intangible assets) is statistically significant and positive. Similar results can be seen in model 4, where the ratio of intangible assets to sales is used as a proxy for innovation. This implies that intangible assets significantly and positively affect the market value of sample firms supporting our first hypothesis. The control variable (size) is significant and positively related to the market value of the company in all 4 models, supporting our third hypothesis and consistent with Lin and Chen findings (2005). The implication of this result is that large companies have more advantages for technological innovation, since they have better access to more sources of financing to support such investment. More innovation in products and services

can lead the company studied to better competitive advantages and a larger market share, hence, more sales, more revenues and higher growth potential. All these lead to higher market value.

Regarding the third explanatory variable, (Country), our results in models 1 and 2 support our fourth hypothesis in the sense that the variable (Country) significantly affects the effect of R&D on company value. However, this effect is positive in the case of R&D expenses and negative in the case of the R&D ratio to sales (RDS). Regarding the variable (Intangible assets) (model 3) and the ratio of intangibles to total assets (model 4), as proxy variables for innovation, it is noted that the variable (Country) is not statistically significant, rejecting our fourth hypothesis. So, it can be concluded that, since we did not have many data regarding the variable (R&D expenses) in Bulgaria, because they are not obliged to report them, we cannot rely on models 1 and 2 that use this variable for innovation to make any inferences concerning the influence of the country factor to the impact of innovation on firm value. Since we had more data for the variable (Intangible assets), for all three countries, the results of models 3 and 4 are more reliable regarding this control variable. From these latter models, 3 and 4, it can be inferred that, for the three Balkan Black Sea countries, the country factor did not have any influence on the impact of innovation to firm value, rejecting our fourth hypothesis.

Table 3a depicts results regarding the influence of variable (R&D expenses) in two forms, namely, as (R&D) and as a ratio of R&D to sales (RDS) and the influence of (intangible assets), along with the other explanatory variables, (size) and (country), on the company's market value (MV) for the period before the COVID-19 pandemic crisis. We checked for autocorrelation and, in all models reported, there is positive autocorrelation since the Durbin and Watson (DW) statistic is less than 2.

Regarding the independent variable R&D expenses for the pre-COVID-19 period, results in Table 3a, models 1 and 2, indicate that the coefficients of explanatory variables (R&D) and (RDS), respectively, are statistically significant and positive, the former having stronger impact. This implies that R&D expenditure significantly and positively affects the market value of sample firms in the pre-COVID-19 period. This result is consistent with our first hypothesis and the studies of Johnson and Pazderka (1993), Abrahams and Sidhu (1998), Ho, Keh and Ong (2005), Harhoff (2006) and VanderPal (2015).

Regarding the independent variable (intangible assets) for this subperiod, results in Table 3a, model 3, indicate that the coefficient of the explanatory variable (intangible assets) is statistically significant and positive. Similar results can be seen in model 4, where the ratio of intangible assets to sales is used as a proxy for innovation. This implies that intangible assets significantly and positively affect the market value of the sub-sample firms supporting our first hypothesis. The control variable size is significant and positively related to the market value of the company in all 4 models, supporting our third hypothesis and consistent with Lin and Chen findings (2005). The implication of this result has been discussed for the entire sample and it is the same.

Table 3. Regression Analysis of Innovation Effect on Market Value for the entire period 2000-2020

Models. Dependent: **MV** Independent Variables	**Beta coef.**	**t-test**	**Sign**	**R^2**	**D-W**
1. Constant	19343422913.83			0.428	0.616
R&D	52.896*	21.163	0.000		
Size	770666052.054*	20.550	0.000		
Country	1996782802.055*	3.203	0.001		
2. Constant	-1.349E+10			0.309	0.535
RDS	1904700327*	6.243	0.000		
Size	1110297212*	27.219	0.000		
Country	-1949652142	-2.997	0.003		
3. Constant	-9734552498			0.157	0.494
Intangible Assets	1.051*	20.740	0.000		
Size	583608156.8*	21.759	0.000		
Country	-24928198.9	-0.369	0.712		
4. Constant	-1.205E+10			0.103	0.471
INTANGA	56973047.95**	2.138	0.033		
Size	710202026.6*	26.270	0.000		
Country	39291715.38	0.563	0.573		

Source: Authors' results based on statistical analysis. * Statistical significance at the 1% level. ** Statistical significance at the 5% level. *** Statistical significance at the 10% level.

Regarding the third explanatory variable, (Country), our results, in model 1, depict a non- significant relationship, while, in model 2, results support our fourth hypothesis in the sense that the variable (Country) significantly and negatively affects the effect of R&D on company value. Regarding the variable (Intangible assets) (model 3), we note that the variable (Country) is negative and statistically significant, supporting our fourth hypothesis. However, the ratio of intangibles to total assets (model 4), as

a proxy variable for innovation, has no statistically significant relationship with the control variable (Country). So, we can conclude that the country factor for the three Balkan Black Sea countries negatively affects the impact of innovation on firm value.

Table 3a. Regression Analysis of Innovation Effect on Market Value before COVID-19 (2000-2019)

Models. Dependent: **MV** Independent Variables	**Beta coef.**	**t-test**	**Sign**	**R^2**	**D-W**
1. Constant	-1.430E+10			0.407	2.007
R&D	44.155*	18.215	0.000		
Size	678124252.8*	19.890	0.000		
Country	866676265.6	1.469	0.142		
2. Constant	-7766365804			0.312	2.041
RDS	1586147220*	5.994	0.000		
Size	941309842.5*	25.716	0.000		
Country	-2857580175	-4.827	0.000		
3. Constant	-8432150584			0.146	1.949
Intangible Assets	1.149*	20.529	0.000		
Size	520124926.9*	19.686	0.000		
Country	-133259436**	-2.018	0.044		
4. Constant	-1.067E+10			0.146	1.934
INTANGA	53741617.9**	2.114	0.035		
Size	642292161.7*	24.073	0.000		
Country	-64883268	-0.950	0.342		

Source: Authors' results based on statistical analysis. * Statistical significance at the 1% level. ** Statistical significance at the 5% level. *** Statistical significance at the 10% level.

Table 3b. Regression Analysis of Innovation Effect on Market Value during COVID-19 (year 2000).

Models. Dependent: **MV** Independent Variables	**Beta coef.**	**t-test**	**Sign**	**R^2**	**D-W**
1. Constant	-5.767E+10			0.622	1.918
R&D	75.048*	6.959	0.000		
Size	226119561*	7.572	0.000		
Country	5336837071***	1.711	0.090		
2. Constant	-8.297E+10			0.484	1.673
RDS	1.239E+10**	1.985	0.049		
Size	3389985301*	10.442	0.000		
Country	6641961245***	1.825	0.071		
3. Constant	-2.501E+10			0.266	1.605
Intangible Assets	0.590*	3.925	0.000		
Size	1262397797*	7.562	0.000		
Country	1411998621*	3.241	0.001		
4. Constant	-2.849E+10			0.238	1.590
INTANGA	277164937	0.545	0.586		
Size	1452985334*	8.830	0.000		
Country	1399098469*	3.095	0.002		

Source: Authors' results based on statistical analysis. * Statistical significance at the 1% level. ** Statistical significance at the 5% level. *** Statistical significance at the 10% level.

Table 3b shows results regarding the influence of the variable (R&D expenses) in two forms, as (R&D) and as a ratio of R&D to sales (RDS) and the influence of intangible assets, along with the other explanatory variables, namely, (size) and (country) on a company's market value (MV) for the period of the year 2020 with the COVID-19 pandemic crisis and the severe hit to global economy. We checked for autocorrelation and in most models reported there is no autocorrelation or a bit

of positive autocorrelation since the Durbin and Watson (DW) statistic is close to 2. Regarding the independent variable (R&D expenses) for the year 2020, i.e., the COVID-19 period, results in Table 3b, models 1 and 2, indicate that the coefficients of the explanatory variables (R&D) and (RDS), respectively, are statistically significant and positive, the former having stronger impact. This implies that R&D expenditure significantly and positively affect the market value of sample firms during the COVID-19 period. This result is consistent with the results for previous time periods. In conclusion, regardless of the time period and the pandemic crisis R&D expenditure significantly and positively affects the market value of the companies in the Romanian and Turkish markets and some of the Bulgarian companies.

Regarding the independent variable (intangible assets), for this crucial year, results in Table 3b, model 3, indicate that the coefficient of the explanatory variable (intangible assets) is positive and statistically significant. A positive correlation is apparent in model 4, where the ratio of intangible assets to sales is used as a proxy for innovation, but it is not significant. This implies that intangible assets significantly and positively affect the market value of sample firms supporting our first hypothesis. The control variable (size) is significant and positively related to the market value of company in all 4 models, supporting our third hypothesis and consistent with Lin and Chen findings (2005).

Regarding the third explanatory variable (Country) our results, in all 4 models, support our fourth hypothesis in the sense that the variable (Country) significantly and positively affects the impact of innovation on company value, supporting our fourth hypothesis. This outcome for the year of the COVID-19 crisis differs from that of previous years, when, in the three Balkan Black Sea countries, the country factor did not have any influence on the impact of innovation on firm value, rejecting our fourth hypothesis.

*4.2 Effect of Innovation (resulting from R&D and Intangibles) on Firm Performanc*e

Tables 4 and 5 refer to the 2000-2020 period and depict only empirical results of the OLS regression analyses of the models with the best explanatory power, regarding the influence of the variable (R&D expenses) in two forms, as (R&D) and as a ratio of R&D to sales (RDS), and the influence of intangible assets, along with the explanatory variables (size) and (country) on a company's performance, measured by return on assets (ROA) and return on equity (ROE), respectively. We checked for autocorrelation and in most models reported there is no autocorrelation since the Durbin and Watson (DW) statistic is close or equal to 2.

Regarding the independent variable (R&D expenses) for the entire period examined, results in Table 4, model 1, indicate that the coefficient of the explanatory variable (R&D) is positive and statistically significant. In model 2, where the ratio of R&D expenses to sales is used as a proxy for innovation, the coefficient of this

explanatory variable is negative but not statistically significant. This implies that R&D expenditure significantly and positively affects performance as measured by profitability ratio ROA for sample firms. This result is consistent with our second hypothesis and the studies of Sher and Yang (2005), Ozdemir *et al*. (2012), Beld (2014), VanderPal (2015), Warusawitharana (2015) and Jaisinghani (2016).

Regarding the independent variable (intangible assets) for the entire period examined, results in Table 4, model 3, indicate that the coefficient of the explanatory variable (intangible assets) is positive and statistically significant. However, in model 4, results indicate that the coefficient of the explanatory variable (intangible assets) to sales ratio is negative but not statistically significant.

This implies that intangible assets significantly and positively affect performance as measured by profitability ratio ROA of sample firms, consistent with our second hypothesis.

The control variable (size) is significant and negatively related to the performance of a company as measured by return on assets ratio (ROA) in all 4 models, contrary to the third hypothesis. The control variable (Country) is positive and significant only in models 3 and 4. As already stated when analyzing results in Table 3, the results in these two models are more reliable since we have data from all three countries. This implies that impact of innovation, as measured by intangible assets, on firm profitability, as measured by ROA, is affected by the country variable, which is consistent with our fourth hypothesis.

Tables 4a and 4b refer to the 2000-2019 period, i.e., before COVID-19 and the COVID-19 period, namely, year 2020, respectively; they depict only empirical results of the OLS regression analyses of the models with the best explanatory power regarding the influence of the variable (R&D expenses) in two forms, as (R&D) and as a ratio of R&D to sales (RDS) and the influence of intangible assets, along with the explanatory variables (size) and (country) on a company's performance, measured by return on assets (ROA) and return on equity (ROE), respectively. We checked for autocorrelation and in most models reported there is no autocorrelation since the Durbin and Watson (DW) statistic is close or equal to 2.

Regarding the independent variable (R&D expenses) for the pre-COVID-19 period, results in Table 4a, models 1 and 2, indicate that the coefficients of the explanatory variable (R&D) and the ratio of R&D expenses to sales, respectively, as proxies for innovation, are not statistically significant. This implies that R&D expenditure does not affect the performance of sample firms as measured by profitability ratio ROA. This result is inconsistent with our second hypothesis and the studies of Sher and Yang (2005), Ozdemir *et al*. (2012), Beld (2014), VanderPal (2015), Warusawitharana (2015) and Jaisinghani (2016).

Table 4. Regression Analysis of Innovation Effect on Performance-ROA

Models. Dependent: **ROA** Independent Variables	**Beta coef.**	**t-test**	**Sign**	**R^2**	**D-W**
1. Constant	57.380			0.020	1.969
R&D	4.255E-8***	1.747	0.081		
Size	-2.286*	-6.259	0.000		
Country	-4.498	-0.741	0.459		
2. Constant	66.076			0.019	1.970
RDS	-1,777	-0.656	0.512		
Size	-2.147*	5.932	0.000		
Country	-8.107	-1.404	0.160		
3. Constant	5.345			0.039	1.718
Intangible Assets	9.550E-11**	2.095	0.036		
Size	-0.356*	-14.211	0.000		
Country	0.735	11.975	0.000		
4. Constant	5.133			0.039	1.718
INTANGA	-0.007	-0.317	0.751		
Size	-0.344*	-14.094	0.000		
Country	0.742	12.066	0.000		

Source: Authors' results based on statistical analysis. * Statistical significance at the 1% level. ** Statistical significance at the 5% level. *** Statistical significance at the 10% level.

Regarding the independent variable (intangible assets) for the entire period examined, results in Table 4a, model 3, indicate that the coefficient of the explanatory variable (intangible assets) is negative and statistically significant. However, in model 4, results indicate that the coefficient of the explanatory variable (intangible assets) to sales ratio is negative but not statistically significant.

This implies that intangible assets significantly and negatively affect performance, as measured by profitability ratio ROA of sample firms, contrary to our second

hypothesis for the pre- COVID-19 period. This result differs from the equivalent one of the entire 2000-2020 time period.

The control variable (size) is significantly negative in relation to the performance of a company, as measured by the return on assets for all 4 models, contrary to the third hypothesis. The control variable (Country) is significantly positive only in models 3 and 4. As we stated before, when analyzing results in Table 4, the results in these two models are more reliable since we have data from all three countries. This result implies that impact of innovation, as measured by intangible assets, on firm profitability, as measured by ROA, is affected by the country variable, consistent with our fourth hypothesis.

Table 4a. Regression Analysis of Innovation Effect on Performance-ROA for the 2000-2019, pre-COVID-19 period.

Models. Dependent: **ROA** Independent Variables	**Beta coef.**	**t-test**	**Sign**	**R^2**	**D-W**
1. Constant	59.973			0.021	1.994
R&D	4.523E-8***	1.633	0.103		
Size	-2.412*	-6.192	0.000		
Country	-4.620	-0.685	0.493		
2. Constant	71.337			0.020	1.996
RDS	-2,032	-0.723	0.470		
Size	-2.297*	-5.913	0.000		
Country	-8.960	-1.426	0.154		
3. Constant	5.021			0.036	1.984
Intangible Assets	-9.825E-11***	1.866	0.062		
Size	-0.335*	-12.953	0.000		
Country	0.687*	10.962	0.000		
4. Constant	4.827			0.035	1.985
INTANGA	-0.006	-0.252	0.801		
Size	-0.324*	-12.853	0.000		
Country	0.694*	11.053	0.000		

Source: Authors' results based on statistical analysis. * Statistical significance at the 1% level. ** Statistical significance at the 5% level. *** Statistical significance at the 10% level.

Table 4b depicts results for the COVID-19 period. Models 1 and 2 indicate that the coefficients of the explanatory variable (R&D) and the ratio of R&D expenses to sales, respectively, used as proxies for innovation, are positive and statistically significant. This implies that R&D expenditure affects the performance of sample firms as measured by profitability ratio ROA. This result is consistent with our second hypothesis and the studies of Sher and Yang (2005), Ozdemir *et al.* (2012), Beld (2014), VanderPal (2015), Warusawitharana (2015) and Jaisinghani (2016).

Table 4b. Regression Analysis of Innovation Effect on Performance-ROA for the period 2020, the COVID-19 period.

Models. Dependent: **ROA** Independent Variables	**Beta coef.**	**t-test**	**Sign**	**R^2**	**D-W**
1. Constant	3.092			0.165	2.029
R&D	3.663E-9*	3.223	0.002		
Size	-0.141*	-4.481	0.000		
Country	0.039	0.119	0.906		
2. Constant	0.836			0.339	1.935
RDS	3,330*	6.648	0.000		
Size	-0.045***	-1.731	0.086		
Country	0.140	0.479	0.633		
3. Constant	13.348			0.141	1.998
Intangible Assets	1.500E-10**	1.544	0.123		
Size	-0.844*	-7.613	0.000		
Country	1.553	5.470	0.000		
4. Constant	12.550			0.137	2.015
INTANGA	-0.184	-0.570	0.569		
Size	-0.802*	-7.478	0.000		
Country	1.589	5.477	0.000		

Source: Authors' results based on the statistical analysis.* Statistical significance at the 1% level. ** Statistical significance at the 5% level. *** Statistical significance at the 10% level.

The independent variables (intangible assets) and intangible assets to sales ratio for the COVID-19 period, in Table 4b, models 3 and 4, respectively, do not influence corporate performance as measured by ROA, in contrast to results for the entire period indicating the impact was positive, and the subperiod without Covid-19, during which the impact was negative. This implies that intangible assets do not affect performance as measured by profitability ratio ROA of sample firms, contrary to our second hypothesis, for the COVID-19 period.

The control variable (size) is significantly negative in relation to the performance of a company as measured by return on assets (ROA) for all 4 models, contrary to the third hypothesis. The control variable (Country) is significantly positive only in models 3 and 4. As already stated, when analyzing results in Table 4, the results in these two models are more reliable since we have data from all three countries. This result implies that impact of innovation, as measured by intangible assets, on firm profitability, as measured by ROA, is affected by the country variable, consistent with our fourth hypothesis.

Regarding the independent variable (R&D expenses) for the entire period examined, results in Table 5, models 1and 2, indicate that the coefficient of the explanatory variable (R&D) and the ratio of R&D expenses to sales as a proxy for innovation, respectively, are not statistically significant. This implies that R&D expenditure does not affect performance as measured by profitability ratio ROE of sample firms. This result is inconsistent with our second hypothesis and the studies of Sher and Yang (2005), Ozdemir *et al*. (2012), Beld (2014), VanderPal (2015), Warusawitharana (2015) and Jaisinghani (2016).

Regarding the independent variable (intangible assets) for the entire period examined, results in Table 5, models 3 and 4, indicate that the coefficient of the explanatory variables (intangible assets) and intangible assets to sales ratio, respectively, are not statistically significant. This implies that intangible assets have no impact on company performance as measured by profitability ratio ROE, inconsistent with our second hypothesis.

The control variable (size) is not significantly related to the performance of a company as measured by return on equity ratio (ROE) in any of the 4 models, contrary to the third hypothesis. The control variable (Country) is also not significant in any of the four models. This result implies that the impact of innovation, as measured by intangible assets on firm profitability, as measured by ROE, is not affected by the country variable and is not consistent with our fourth hypothesis.

Table 5a presents the impact of innovation on profitability ratio return on equity (ROE) for the pre- COVID-19 period. None of the four models analyzed had statistically significant coefficients of the explanatory variables representing innovation, R&D expenses and Intangible assets. This result is inconsistent with our second hypothesis and the studies of Sher and Yang (2005), Ozdemir *et al*. (2012), Beld (2014), VanderPal (2015), Warusawitharana (2015) and Jaisinghani (2016), as well as with the one for the entire time period examined, whereby the innovation had a positive impact on firm performance.

The control variable (size) is positive but not significant in all four models. The control variable (Country) is not significant in all four models. This result implies that the impact of innovation, as measured by R&D, on firm profitability, as measured by ROE, is not affected by company size nor by the country variable. Thus, our results are not consistent with our third and fourth hypotheses for the 2000-2019 period.

Table 5. Regression Analysis of Innovation Effect on Performance-ROE

Models. Dependent: **ROE** Independent Variables	**Beta coef.**	**t-test**	**Sign**	**R^2**	**D-W**
1. Constant	-0.192			0.000	2.062
R&D	9.522E-10	0.599	0.549		
Size	0.005	0.216	0.829		
Country	0.050	0.427	0.549		
2. Constant	-0.163			0.000	2.062
RDS	0.098	0.553	0.589		
Size	0.014	0.585	0.559		
Country	-0.013	-0.033	0.973		
3. Constant	-0.216			0.000	1.993
Intangible Assets	-2.014E-12	-0.074	0.941		
Size	0.011	0.735	0.463		
Country	0.043	1.167	0.243		
4. Constant	-0.211			0.000	1.993
INTANGA	-0.001	-0.081	0.936		
Size	0.010	0.730	0.465		
Country	0.043	1.167	0.243		

Source: Authors' results based on the statistical analysis. * Statistical significance at the 1% level. ** Statistical significance at the 5% level. *** Statistical significance at the 10% level.

Table 5a. Regression Analysis of Innovation Effect on Performance-ROE for the period 2000-2019, pre- COVID-19 period.

Models. Dependent: **ROE** Independent Variables	**Beta coef.**	**t-test**	**Sign**	**R^2**	**D-W**
1. Constant	-0.482			0.001	2.355
R&D	7.910E-10	0.459	0.647		
Size	0.016	0.676	0.499		
Country	0.069	0.165	0.869		
2. Constant	-0.438			0.001	2.355
RDS	0.086	0.492	0.623		
Size	0.024	0.974	0.330		
Country	0.011	0.028	0.978		
3. Constant	-0.262			0.003	2.008
Intangible Assets	-3.802E-12	-0.117	0.907		
Size	0.013	0.863	0.388		
Country	0.042	1.102	0.271		
4. Constant	-0.254			0.003	2.008
INTANGA	-0.001	-0.082	0.935		
Size	0.013	0.851	0.395		
Country	0.042	1.100	0.272		

Source: Authors' results based on statistical analysis. * Statistical significance at the 1% level. ** Statistical significance at the 5% level. *** Statistical significance at the 10% level.

Table 5b presents the impact of innovation on profitability ratio return on equity (ROE) for the COVID-19 period. None of the four models analyzed had statistically significant coefficients of the explanatory variables representing innovation, R&D expenses and Intangible assets. This result is inconsistent with our second hypothesis and the studies of Sher and Yang (2005), Ozdemir *et al.* (2012), Beld (2014), VanderPal (2015), Warusawitharana (2015) and Jaisinghani (2016), similarly to that for the entire time period examined.

The control variable (size) is significantly negative only for models 1 and 2. The control variable (Country) is not significant in any of the four models. This result implies that the impact of innovation, as measured by R&D, on firm profitability as measured by ROE, is affected by company size but not by the country variable. Thus, our results are partially consistent with our third hypothesis but not with our fourth one.

Table 5b. Regression Analysis of Innovation Effect on Performance-ROE for the period 2000-2019, pre- COVID-19 period.

Models. Dependent: **ROE** Independent Variables	**Beta coef.**	**t-test**	**Sign**	**R^2**	**D-W**
1. Constant	10.092			0.065	1.969
R&D	5.251E-9	1.088	0.279		
Size	-0.381*	-2.853	0.005		
Country	-0.702	-0.503	0.616		
2. Constant	7.181			0.077	1.949
RDS	3.913	1.648	0.102		
Size	-0.257	-2.077	0.040		
Country	-0.569	-0.411	0.682		
3. Constant	0.418			0.003	2.039
Intangible Assets	1.007E-11	0.408	0.684		
Size	-0.026	-0.941	0.347		
Country	0.060	0.841	0.401		
4. Constant	0.352			0.003	2.041
INTANGA	0.019	0.236	0.813		
Size	-0.022	-0.830	0.407		
Country	0.057	0.788	0.431		

Source: Authors' results based on statistical analysis. * Statistical significance at the 1% level. ** Statistical significance at the 5% level. *** Statistical significance at the 10% level.

5. Conclusions

This study focused on firms operating in three Balkan countries that are also within the Black Sea region and set out to explore innovation effects on firm value and corporate performance. The paper found a positive correlation between innovative investment, as proxied by research and development expenses and intangible assets, with a firm's value. Results indicated a positive correlation between innovation, as proxied by research and development expenses and intangible assets with a firm's performance, as measured by return on assets (ROA). However, regarding company performance, as measured by ROE, our results rejected our hypothesis since a negative correlation was found between innovation variables and this profitability ratio as performance variable. Regarding the existence of a "size effect", firm size was found to have a positive effect on firm value and a negative one on performance measured by ROA. The control variable (Country) was found to be significant only in the case of intangibles impact on ROA. Based on our results, the COVID-19 crisis affected only the performance of companies but not their value.

Future research could concentrate on the impact of innovation on firm value and firm performance and investigate whether there are any differences among various industries regarding these matters, as more recent literature suggests based on Vrontis and Christofi (2019) and Boiko (2021). The same hypotheses can also be examined for other developed and developing countries to provide further insight to scholars, investors and policy makers concerning the significance of innovation for a company's survival and growth and of the factors affecting it, since innovation is important for companies in terms of strategy, organization, behavior and knowledge, as well as from legal, economic and business perspectives.

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INFLATION, INFLATION UNCERTAINTY, AND MARKOV REGIME SWITCHING HETEROSKEDASTICITY: EVIDENCE FROM EUROPEAN COUNTRIES

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Abstract
We use a Markov regime-switching heteroskedasticity model in order to examine the association between inflation and inflation uncertainty in four European countries over a forty-year period. This approach allows for regime shifts in both the mean and variance of inflation in order to assess the association between inflation and its uncertainty in short and long horizons. We find that this association differs (i) between transitory and permanent shocks to inflation and (ii) across countries. In particular, the association is positive or zero for transitory shocks and negative or zero for permanent shocks. Hence, Friedman's belief that inflation is positively associated with inflation uncertainty is only partially supported in this study, i.e., with short-run inflation uncertainty.

JEL Classification: C22, C51, C52, E0
Keywords: Inflation, Inflation uncertainty, Markov process, regime-switching heteroskedasticity

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1. Introduction

The issue of the welfare costs of inflation has drawn the attention of macroeconomists for many years at both theoretical and empirical levels. In fact, the recent emphasis on price stability, expressed for practical purposes as low and stable inflation, among the world's major Central Banks, including the Federal Reserve System and the European Central Bank (ECB), is predicated on the assumed adverse impact of inflation on economic efficiency. Lucas (2000) estimates the welfare gain of reducing inflation from 14% to 3% at about 0.8% of US real GDP irrespective of the explicit form assumed by the money demand function[1]. It is widely accepted that the focus of monetary policy on price stability is the main cause of the low inflation rates achieved by several industrialized countries (Greenspan, 2004).

Considerable ambiguity surrounds the impact of the average rate of inflation on the rate of economic growth at the theoretical level. Furthermore, the impact of inflation on output growth may take place indirectly, via the inflation uncertainty channel. In his Nobel lecture, Friedman (1977) argues that a rise in the average rate of inflation leads to more uncertainty about the future rate of inflation, distorts the effectiveness of the price mechanism in allocating resources efficiently, and, thus, creates economic inefficiency and a lower level of output. Moreover, by affecting interest rates, inflation uncertainty also impacts the intertemporal allocation of resources. Hence, a comprehensive empirical study that tests for the real effects of inflation should control for the impact of inflation uncertainty on output. The positive correlation between inflation and inflation uncertainty reported in empirical studies can also arise from a positive causal effect of inflation uncertainty on inflation. Cukierman and Meltzer (1986) provide a theoretical model that explains such a causal effect. In the presence of more inflation uncertainty, less conservative central bankers have an incentive to surprise the public and generate unanticipated inflation, hoping for output gains.

The empirical assessment of the relationship between inflation uncertainty and inflation may be based on various approaches. Early studies focus on the variability (as opposed to uncertainty) of inflation and test for the correlation between inflation and inflation variability. The consensus reached by these studies is that inflation variability is positively correlated with inflation. Following Engle's (1982) pathbreaking paper on Autoregressive Conditional Heteroskedasticity (ARCH) models, researchers measured uncertainty by the conditional variance of unanticipated shocks to inflation. This allowed for a time-varying measure of inflation uncertainty. Engle

1. Most estimates of the cost of inflation are less than 1% of output suggesting that the costs of inflation are very low. An exception is that of Bullard and Russell (2004) who find that the annual cost of a 10% inflation rate is 11.2% of output.

(1983) finds that a rise in inflation in the current quarter does not lead to an increase in uncertainty in the next quarter. Subsequent studies summarised by Holland (1993) and Davis and Kanago (2000) find mixed evidence regarding the association between inflation and inflation uncertainty using a variety of methodologies. More recently, Grier and Perry (1998), using the Generalised ARCH (GARCH) approach, test for bidirectional causality between inflation and inflation uncertainty in the G7. The authors find that, first, inflation positively affects inflation uncertainty in all countries and, second, there is mixed evidence across countries regarding the effect of inflation uncertainty on inflation. However, Fountas and Karanasos (2007) find mixed evidence regarding the causal relationship between inflation and inflation uncertainty.

The approaches mentioned above, regarding the association between inflation and inflation uncertainty, usually examine this association at either short run or long-run horizons. For instance, pre-GARCH studies test for the effects of inflation on its uncertainty variability over several years whereas many GARCH studies test for the short-run (or next-quarter) effect. Ball and Cecchetti (1990) argue that association between inflation and its uncertainty may differ between short-run and long-run horizons. Some simple correlation analyses between the mean and variance of US inflation in the 1954-89 period reported by the authors indicates that these correlations become larger as the horizon considered increases. These results are confirmed by a more formal approach that distinguishes between permanent and temporary shocks to inflation. Motivated by the Ball and Cecchetti (1990) approach, Kim (1993) proposes a model of Markov-switching heteroskedasticity, which is deemed superior to the GARCH approach for three reasons. First, this approach allows for the possibility of regime shifts. Second, the Markov regime-switching approach permits the consideration of temporary and permanent shocks to inflation, thus allowing examination of the effects of inflation on short run and long-run uncertainty about inflation. Third, in contrast to the GARCH approach, this model allows for nonconstant unconditional variance.

In this paper, the relationship between inflation uncertainty and inflation are analyzed empirically using a model that allows for Markov regime-switching heteroskedasticity concerning four European countries. Our chosen econometric model is similar to that employed by Kim (1993) and it is applied to quarterly inflation data over a forty-year period. Our results are likely to shed some light on the empirical relationship between inflation and inflation uncertainty. In particular, they will indicate whether inflation uncertainty is associated with inflation, as predicted by Friedman (1977). This is a necessary requirement for welfare costs of inflation that work via the inflation uncertainty channel. Moreover, the results will show whether there is evidence that higher inflation is associated with more uncertainty about long-run inflation or short-run inflation or both. Finally, our

methodological approach will indicate whether short-run and long-run inflation uncertainty positively or negatively affects the rate of inflation, as predicted by Cukierman and Meltzer (1986) and Holland (1995), respectively.

The paper is outlined as follows: Section 2 discusses the theoretical basis for the relationship between inflation and inflation uncertainty. Section 3 summarizes empirical literature to date on the association between inflation and uncertainty about the rate of inflation. Section 4 presents our econometric model and section 5 reports and discusses our results. Finally, Section 6 summarizes our main conclusions and draws some policy implications.

2. Theoretical background

2.1 The impact of inflation on inflation uncertainty

Economists have appealed to the uncertainty about the future rate of inflation in order to account for the welfare loss that monetary economics has associated with inflation. Predictable inflation should not lead to welfare loss since indexation will allow agents to minimize the costs of inflation. However, uncertainty about future inflation distorts efficient allocation of resources based on the price mechanism. Friedman (1977) presents an informal argument regarding the real effects of inflation; his argument represents one of the few existing arguments on the rationalization of welfare effects of inflation and comes in two parts. In the first leg of Friedman hypothesis, an increase in inflation may induce an erratic policy response by the monetary authority and, therefore, lead to more uncertainty about the future rate of inflation. As Friedman (1977, p. 466) wrote: "A burst of inflation produces strong pressure to counter it. Policy goes from one direction to another, encouraging wide variation in the actual and anticipated rate of inflation... Everyone recognizes that there is great uncertainty about what actual inflation will turn out to be over any specific future interval." The second part of Friedman's hypothesis predicts that increased inflation uncertainty would increase the rates of unanticipated inflation observed and, hence, will be associated with the costs of unanticipated inflation. Such costs arise from the effect of inflation uncertainty on both intertemporal and intratemporal allocation of resources. Combining the link of inflation to inflation uncertainty and the link of inflation uncertainty to output, a testable hypothesis is obtained, i.e., that higher inflation leads to lower output, i.e., a positively sloped Phillips curve[2].

2. The effect of inflation uncertainty on output was formally addressed by Dotsey and Sarte (2000). In a cash-in-advance model, which allows for precautionary savings and risk aversion, they show that more inflation uncertainty can have a positive output growth effect. According to the authors' argument, an increase in the variability of monetary growth, and, therefore, inflation, makes the return to money balances more uncertain and leads to a fall in demand for real money balances and consumption. Hence, agents increase precautionary savings, and the pool of funds available to finance investment increases. This result is analogous to literature finding that indicates fiscal policy uncertainty is conducive to growth by encouraging precautionary savings.

Subsequently, Friedman's intuitive result was formally derived by Ball (1992) in an asymmetric information game, in which the public faces uncertainty about the type of the policymaker (monetary authority). The two policymaker types differ in terms of their willingness to bear the economic costs of reducing inflation. In periods of low inflation, the tough type will apply contractionary monetary policy. Ball assumes that the two types of policymakers alternate in office in a stochastic manner. Therefore, a higher current inflation rate creates more uncertainty about the level of future inflation since it is not known whether the tough type will gain power and fight inflation.

2.2 The impact of inflation uncertainty on inflation

The opposite direction of causality to that examined by Friedman in the inflation/inflation uncertainty relationship has also been addressed in theoretical literature that examines the impact of a change in inflation uncertainty on the average rate of inflation. Cukierman and Meltzer (1986) employ a Barro-Gordon model, in which agents face uncertainty about the rate of monetary growth and, therefore, inflation. In the presence of this uncertainty, the policymaker applies an expansionary monetary policy in order to surprise agents and enjoy output gains. This argument implies a positive causal effect from inflation uncertainty to inflation and has been dubbed 'the Cukierman-Meltzer hypothesis' by Grier and Perry (1998). Holland (1995) supplied a different argument based on the stabilization motive of the monetary authority, the so-called "stabilizing Fed hypothesis". He claims that, as inflation uncertainty rises due to increasing inflation, the monetary authority responds by contracting money supply growth, in order to eliminate inflation uncertainty and the negative welfare effects associated with it. Hence, Holland's argument supports the opposite sign in the causal relationship, i.e., a negative causal effect of inflation uncertainty on inflation. The theoretical ambiguity surrounding this causal relationship necessitates an empirical investigation of the sign of the effect.

3. The empirical evidence

Early empirical studies on the relationship between inflation and its uncertainty used the variance (or standard deviation) as a measure of uncertainty and, hence, measured inflation variability as opposed to uncertainty. The use of the autoregressive conditional heteroskedasticity (ARCH) and generalized ARCH (GARCH) approaches, introduced by Engle (1982) and Bollerslev (1986), respectively, allows us to proxy uncertainty using the conditional variance of unpredictable shocks to the inflation rate. Engle (1983) and Bollerslev (1986), making use of the ARCH techniques, do not perform a statistical test of the Friedman-Ball hypothesis but only compare the conditional variance series estimated with the US average inflation rate over various time periods. Engle (1983), in an application of the

ARCH approach, finds that US inflation is not related to inflation uncertainty, which is inconsistent with the Friedman-Ball hypothesis[3]. Grier and Perry (1998) use the estimated conditional variance from a GARCH model and employ Granger-causality tests to test for the direction of causality between average inflation and inflation uncertainty. Baillie et al. (1996) perform these tests simultaneously in a single model by including lagged inflation in the conditional variance equation and conditional standard deviation in the inflation equation. More specifically, using G7 data, Grier and Perry (1998) find that inflation has a significant and positive effect on inflation uncertainty in all countries[4]. On the other hand, Baillie *et al.* (1996) find no significant relationship between inflation and inflation uncertainty. More recently, Karanasos *et al.* (2004), using a GARCH-in-Mean (GARCH-M) model enriched with lagged inflation in the conditional variance equation, find that US inflation positively affects inflation uncertainty, a result supporting the Friedman-Ball hypothesis. A similar model applied by Fountas (2001), using historical UK data, shows support for the Friedman-Ball hypothesis.

The causal impact of inflation uncertainty on inflation is tested empirically, using the GARCH approach, in Baillie *et al.* (1996), Grier and Perry (1998, 2000), Grier *et al.* (2004) and Fountas *et al.* (2004). Grier and Perry (2000) and Grier *et al.* (2004) use only US data, whereas the rest of the studies use international data. In general, the evidence is mixed. Baillie *et al.* (1996) find evidence supporting the link between the two variables for the UK and some high-inflation countries, whereas Grier and Perry (1998), in their G7 study, find evidence in favor of the Cukierman-Meltzer hypothesis for some countries and in favor of the Holland hypothesis for other countries. Fountas *et al.* (2004) also obtain mixed evidence. Finally, Grier and Perry (2000) and Grier *et al.* (2004) find evidence for a zero and negative effect of inflation uncertainty on inflation in the US, respectively.

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3. The evidence on the impact of inflation uncertainty on growth is more limited and is summarized in Holland (1993). GARCH studies on this matter, which represent a more accurate test of the hypothesis that inflation uncertainty has negative welfare effects, are mostly based on US data (e.g., Coulson and Robins, 1985; Jansen, 1989; Grier and Perry, 2000, Grier *et al.* 2004). Exceptions are the studies by Fountas and Karanasos (2007), Fountas *et al.* (2006) and Fountas *et al.* (2004). The first two studies use data on the G7 and the last one uses data on six European countries. The evidence is rather mixed. Grier and Perry (2000) and Grier *et al.* (2004) find evidence indicating a negative effect. In contrast, Coulson and Robins (1985) and Jansen (1989) find evidence pointing to a positive and zero effect, respectively. Fountas *et al.* (2004) and Fountas and Karanasos (2006) find mixed evidence using a two-step approach that combines the estimation of a GARCH model with the implementation of Granger-causality tests.
4. Using a Component GARCH-M model of inflation, which includes lagged inflation in the conditional variance, Grier and Perry (1998) simultaneously estimate the relationship between inflation and inflation uncertainty. They find that inflation has a positive effect on inflation uncertainty (the Friedman-Ball hypothesis), but uncertainty has no significant impact on inflation.

GARCH models have a potential disadvantage: they cannot account for regime shifts that may affect both the mean and the variance of inflation. Bhar and Hamori (2004), applying the Kim (1993) model for the G7 for the 1961-1999 period, find that inflation is positively related to long-run uncertainty in some countries and positively or negatively related to short-run uncertainty (depending on the country considered).

4. Econometric Methodology

We adopt the Kim (1993) approach, according to which two different volatility regimes, conditional and unconditional, are determined by two different Markov-switching processes. The following equation decomposes inflation into its two components:

$$\pi_t = \mathrm{T}_t + \mu_2 S_{1,t} + \mu_3 S_{2,t} + \mu_4 S_{1,t} S_{2,t} + (h_0 + h_1 S_{2,t}) e_t \tag{1}$$

$$T_t = T_{t-1} + (Q_0 + Q_1 S_{1,t}) v_t \tag{2}$$

In the two equations above, both v_t and e_t are N(0,1). The empirical model in equations (1) and (2) was first discussed by Ball and Cecchetti (1990). It decomposes inflation into two components, a stochastic and a stationary one with shocks to these two components represented by v_t and e_t, respectively. For example, trend inflation is determined by trend money growth and examples of shocks may include a rise in trend inflation to take account of supply side shocks. The effect of shocks to the stochastic trend feed through to inflation via equation (2) above. Transitory shocks (e_t) are also represented and take account of any shock resulting in inflation deviating from its trend. These may be demand (e.g., monetary policy) shocks or supply shocks. In equations (1) and (2), $S_{1,t}$ and $S_{2,t}$ are unobserved state variables that determine the regime for the trend and temporary component, respectively. It is assumed that $S_{1,t}$ and $S_{2,t}$ evolve independently of each other. A two-state Markov switching process is adopted with values of 0 taking account of the low-variance state and values of 1 of the high-variance one. The two-state Markov process takes on the following transition probabilities:

$$Pr[S_{1,t} = 0 \mid S_{1,t-1} = 0] = p_{00},\ Pr[S_{1,t} = 1 \mid S_{1,t-1} = 1] = p_{11},$$

$$Pr[S_{2,t} = 0 \mid S_{2,t-1} = 0] = q_{00},\ Pr[S_{2,t} = 1 \mid S_{2,t-1} = 1] = q_{11} \tag{3}$$

where regime 1 is characterized by low Q_t and low h_t, ($S_{1,t} = 0$, $S_{2,t} = 0$), regime 2 by a low Q_t and high h_t, ($S_{1,t} = 0$, $S_{2,t} = 1$), regime 3 by high Q_t and low h_t, ($S_{1,t} = 1$, $S_{2,t} = 0$) and, finally, regime 4 characterized by high Q_t and high h_t, ($S_{1,t} = 1$, $S_{2,t} =$

1). For example, in equation 3, p_{00} is the probability that the trend component will remain in regime 1. The effect of uncertainty on inflation is represented by μ_2, μ_3 and μ_4. μ_2 indicates the effect of uncertainty associated with the high inflation state for the permanent (long- run) component, while μ_3 indicates the effect of uncertainty associated with the high inflation state for the temporary (short-run) component. It may be the case that the effect on inflation may be non-linear, and, as a result, we also include the interaction between the two, μ_4. This term captures the effect of a change in both short-run and long-run uncertainty on inflation. Finally, Q_1 (Q_0) represents the increase in the variance of the trend component during the high (low) variance state and h_1 (h_0) represents the increase in the variance of the temporary component during the high (low) variance state.

5. Data and results

5.1 Data

We use quarterly data on the GDP deflator as a proxy for the price level (the only exception being Italy, where, in the absence of a long time series, CPI is used instead). The data refer to four European countries, namely, Germany, Italy, Holland, and the UK. The sample starts in 1966 (except for Holland and Italy, for which it starts in 1977 and 1960, respectively) and ends in the first quarter of 2005. All data are taken from the International Financial Statistics published by the IMF. Inflation is measured by the quarterly difference of the logarithm of the GDP deflator $[\pi_t = \log(\frac{\mathrm{PI}_t}{\mathrm{PI}_{t-1}})]$. We first test for the stationarity properties of our data using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. The results of these tests (not reported) indicate that we can treat the inflation rate in each country as a nonstationary process[5].

5.2 Results

Table 1 reports estimates of the Markov regime-switching model of inflation. Specifically, we include estimates of the transition probabilities, the Q_s, the hs and the μ_s. With very few exceptions, all probabilities estimated are close to one and statistically significant, a finding consistent with regime switching. In two of the four countries (Italy and the UK), μ_2 is negative and significant at 5% implying that an increase in long-run uncertainty leads to lower inflation, which supports the theoretical argument of Holland (1995). In contrast, in two of the four countries (Holland and the UK), μ_3 is positive and significant at 5% implying that an increase in short-run uncertainty raises average inflation, supporting the Cukierman-Meltzer hypothesis. In half of the countries examined, both short-run and long-run

5. Results are made available by the authors upon request.

uncertainty regarding inflation have no impact on inflation. Finally, parameter μ_4 is positive and significant in three of the four cases considered implying that an increase in both long-run and short-run uncertainty raises average inflation.

Figures 1-8 plot the inflation rate and the probability of being in the high-variance state for permanent and transitory (temporary) shocks in the four countries. Inflation (the probability of the high-variance state) is measured along the left-hand (right-hand) side vertical axis. A close look at the figures representing inflation and the probability of a high-variance state for permanent shocks leads to the following observations:

(1) The probability of a high-variance state varies widely across countries. However, in some countries (the UK and Italy) it is observed that these probabilities are quite high (close to one) during the times of oil price shocks, namely, 1973-74 and 1979. In addition, the probability for Italy is close to zero in 1979, the year the country joined the European Monetary System.

(2) There is evidence for structural change in several countries. For example, in the UK, the probability of high-income state is close to one in the second half of the 1970s. Similarly, this probability is very high for Italy in 1973-79 and in 1962 and in Holland for several years in the early 1990s. In contrast, for Germany the probability is never lower than 0.5, most likely indicating the absence of regime changes. This evidence supports the choice of Markov regime-switching heteroskedasticity methodology.

(3) In Italy and the UK there seems to exist a negative association between inflation and the probability of a high-variance state for permanent shocks. In other words, inflation and long-run inflation uncertainty are negatively related. This agrees with the negative sign of μ_2. This finding contradicts the Friedman-Ball hypothesis.

A close look at the figures that plot the rate of inflation and the probability of a high-variance state for the transitory shocks reveals the following:

(1) The probability of a high variance state for transitory shocks varies significantly across countries. This probability is quite high (close to 1) for the UK in 1974, for Germany in the early 1970s and early 1990s (post-reunification years). In contrast, the probability is close to zero for Italy in 1979, the year it joined the EMS.

(2) There is evidence for structural change in several countries. For example, in Germany the probability is close to 1 for several quarters in the early 1970s, for Italy the probability is close to zero in 1979, and for Holland the probability is close to zero in 1998 and quite low in the following quarters.

(3) A positive association between inflation and the probability of the high-variance state for transitory shocks is evident for Holland and the UK. This is consistent with the positive sign of μ_3. Similarly, inflation and uncertainty about short-run

inflation are positively related. This evidence is consistent with the Friedman-Ball hypothesis. As inflation rises above normal, the public is facing more uncertainty regarding the response of the monetary authority, which may be accommodating or dis-inflating.

6. Conclusions

We use a Markov regime-switching heteroskedasticity model in order to examine the association between inflation and inflation uncertainty in four European countries over a forty-year period. This approach allows for regime shifts in both mean and variance of inflation in order to assess the association between inflation and its uncertainty in short and long horizons. We find that this association differs (i) between transitory and permanent shocks to inflation and (ii) across countries. In particular, the association is positive or zero for transitory shocks and negative or zero for permanent shocks. Hence, Friedman's belief that inflation is positively associated with inflation uncertainty is only partially supported in this study, i.e., with short- run inflation uncertainty. The evidence for regime shifts highlights the advantage of such an approach as compared to the GARCH methodology, according to which such regime changes are not accounted for.

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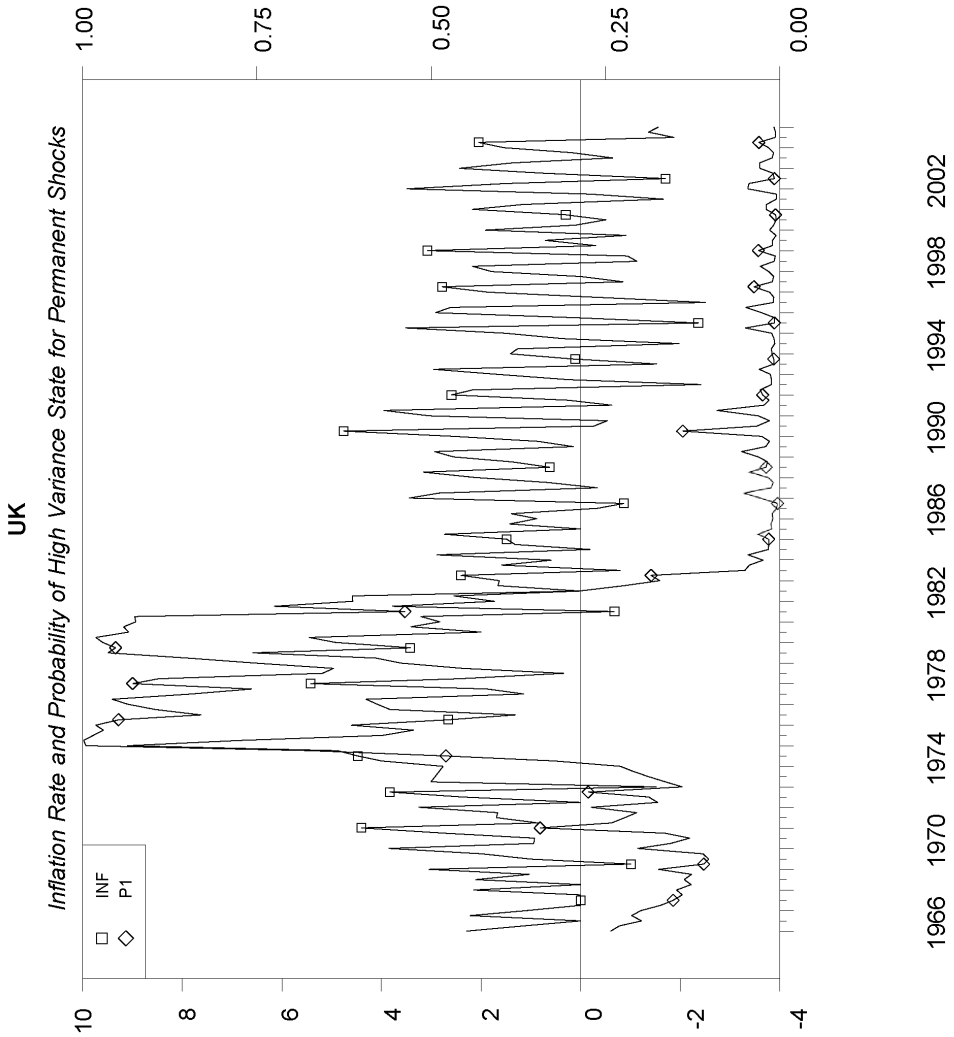
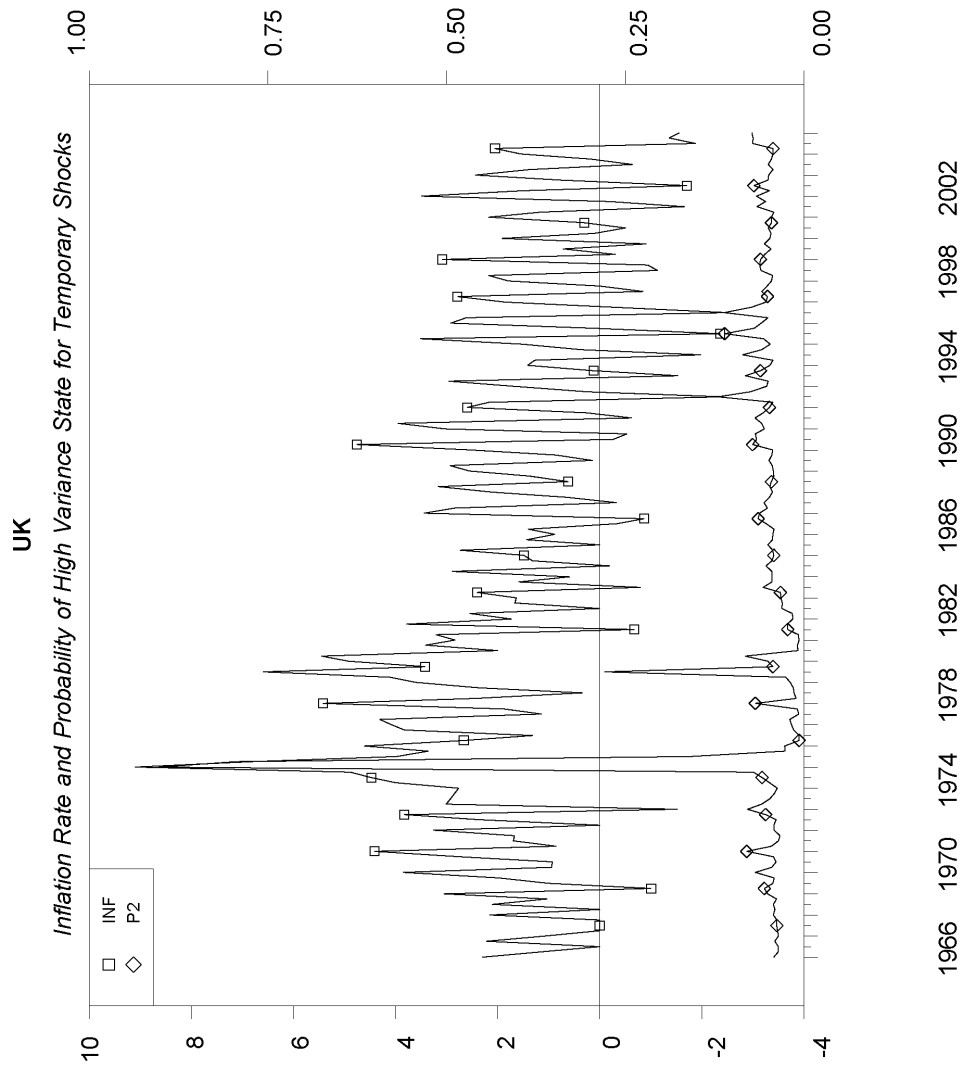
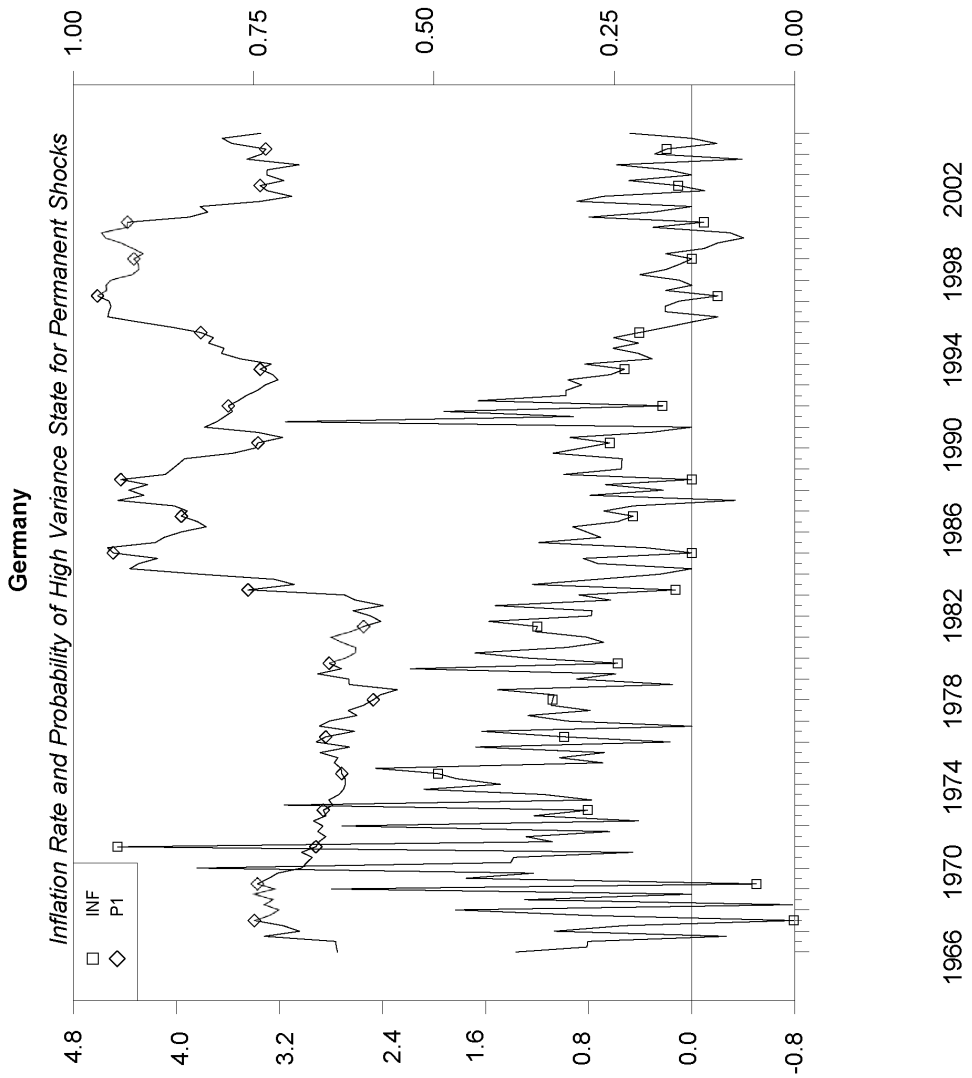
Table 1. Markov Switching Model of Inflation

	Germany	Holland	Italy	UK
	(1966.I-2005.I)	(1977.I-2005.I)	(1966.I-2005.I)	(1966.I-2005.I)
Q_0	0.001	0.0001	0.1245*	0.0599
	(0.0777)	(0.0225)	(0.0374)	(0.0532)
Q_1	0.0600	0.0001	1.2329*	0.0001
	(0.0825)	(0.0014)	(0.2247)	(0.0001)
$h0$	0.3729*	0.4442*	0.0001	1.5367
	(0.0363)	(0.0545)	(0.0015)	(0.0975)
$h1$	0.7491*	1.2693*	0.4546*	0.3415
	(0.1322)	(0.4159)	(0.0369)	(0.5634)
$\mu 2$	0.4171	0.2217	-2.3195*	-0.1350*
	(0.5647)	(0.4566)	(0.5397)	(0.0002)
μ_3	-0.2157	0.5896*	0.1266	1.9422*
	(0.3646)	(0.1802)	(0.2540)	(0.5722)
μ_4	0.0812	3.6081*	1.2855*	3.4291*
	(0.8829)	(1.2543)	(0.4257)	(0.0003)
$p00$	0.9805*	0.8635*	0.8821*	0.9726*
	(0.0711)	(0.1343)	(0.0633)	(0.0306)
$p11$	0.9550*	0.9758*	0.9745*	0.9910*
	(0.1038)	(0.0217)	(0.0162)	(0.0082)
$q00$	0.9365*	0.3270	0.9930*	0.4303
	(0.0445)	(0.2207)	(0.0068)	(0.3852)
$q11$	0.9769*	0.9132*	0.9445*	0.9665*
	(0.0173)	(0.0533)	(0.0599))	(0.0431)

Full details on each of the parameters are discussed in the methodology section in the text.
Standard errors are in parenthesis.
Significance at the 5% level is indicated by a *.


UK
Inflation Rate and Probability of High Variance State for Permanent Shocks
INF
P1
10
8
6
4
2
0
-2
-4
1.00
0.75
0.50
0.25
0.00
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002


UK
Inflation Rate and Probability of High Variance State for Temporary Shocks
INF
P2
10
8
6
4
2
0
-2
-4
1.00
0.75
0.50
0.25
0.00
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002


Germany
Inflation Rate and Probability of High Variance State for Permanent Shocks
INF
P1
4.8
4.0
3.2
2.4
1.6
0.8
0.0
-0.8
1.00
0.75
0.50
0.25
0.00
1966
1970
1974
1978
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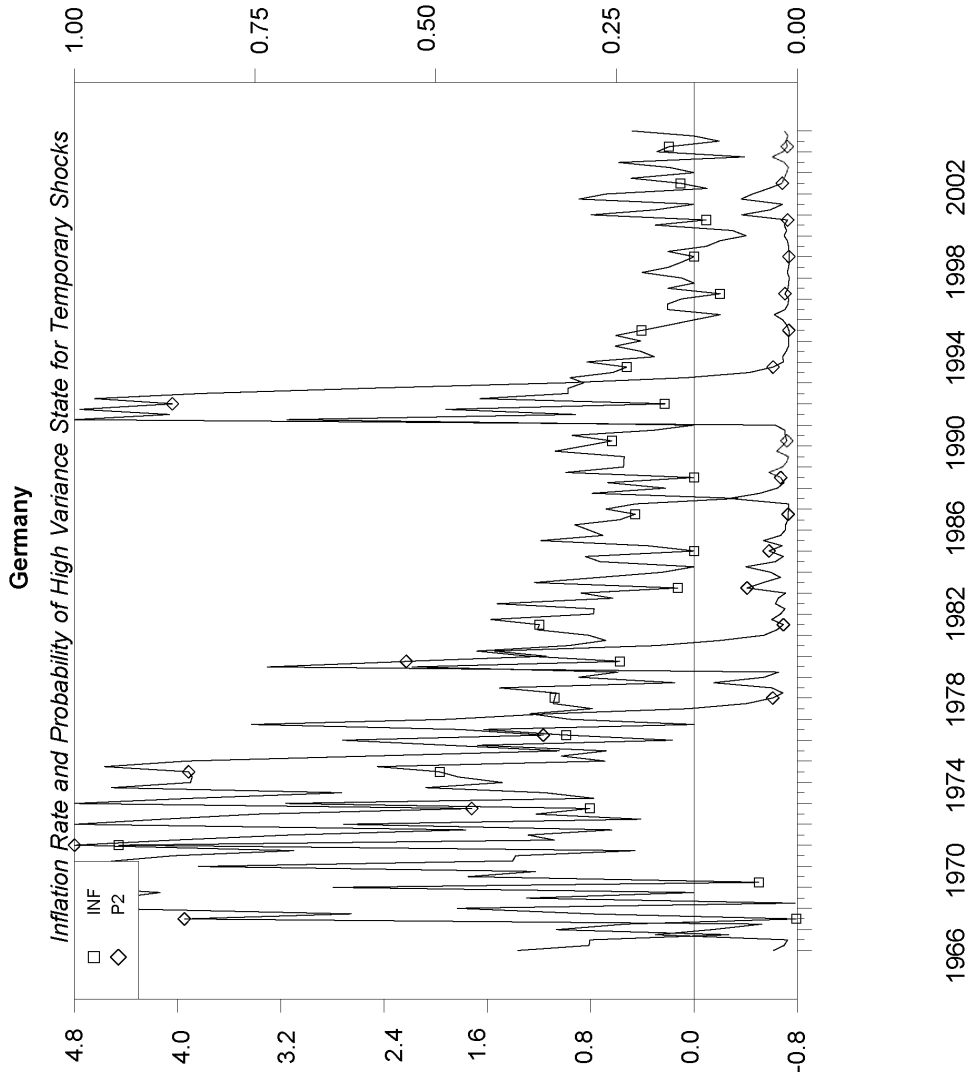
1998
2002


Germany
Inflation Rate and Probability of High Variance State for Temporary Shocks
INF
P2
4.8
4.0
3.2
2.4
1.6
0.8
0.0
-0.8
1.00
0.75
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0.25
0.00
1966
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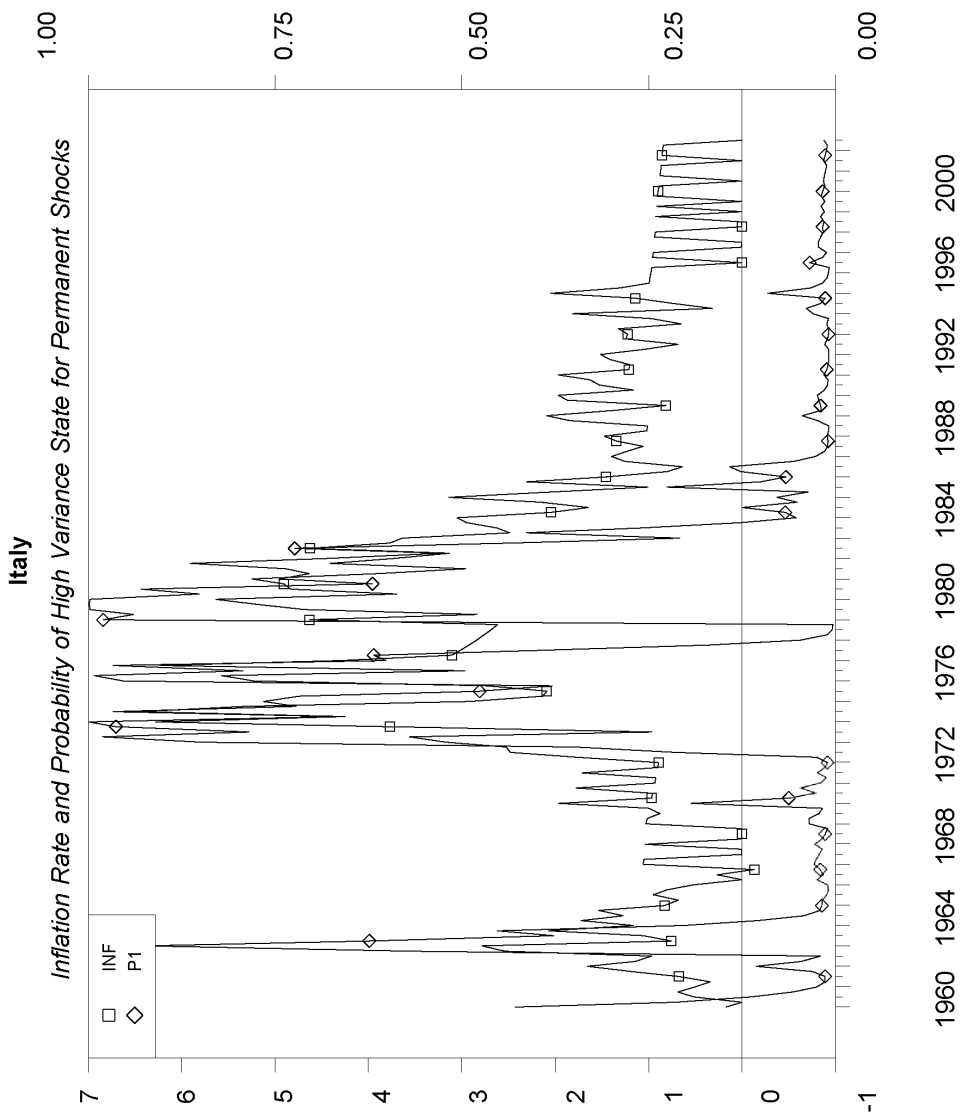
Italy
Inflation Rate and Probability of High Variance State for Permanent Shocks
INF
P1
7
6
5
4
3
2
1
0
-1
1.00
0.75
0.50
0.25
0.00
1960
1964
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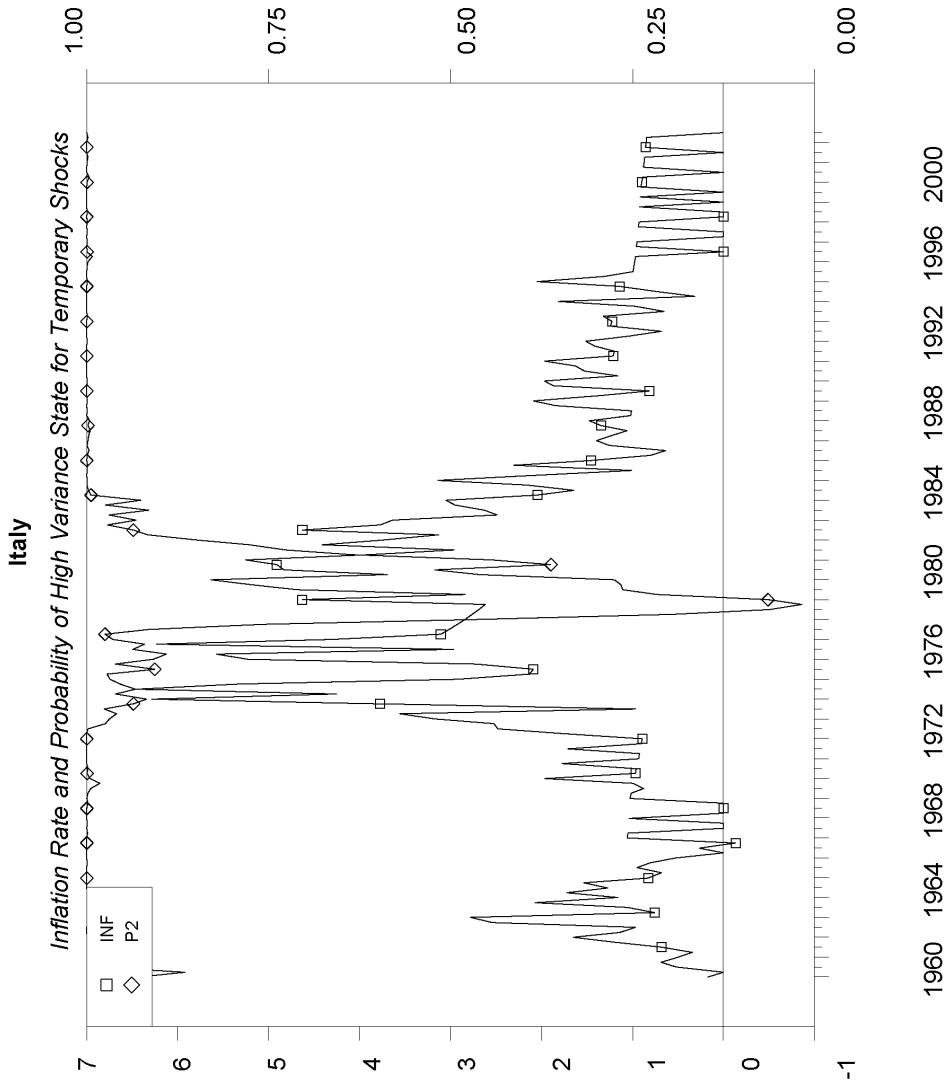
Italy
Inflation Rate and Probability of High Variance State for Temporary Shocks
INF
P2
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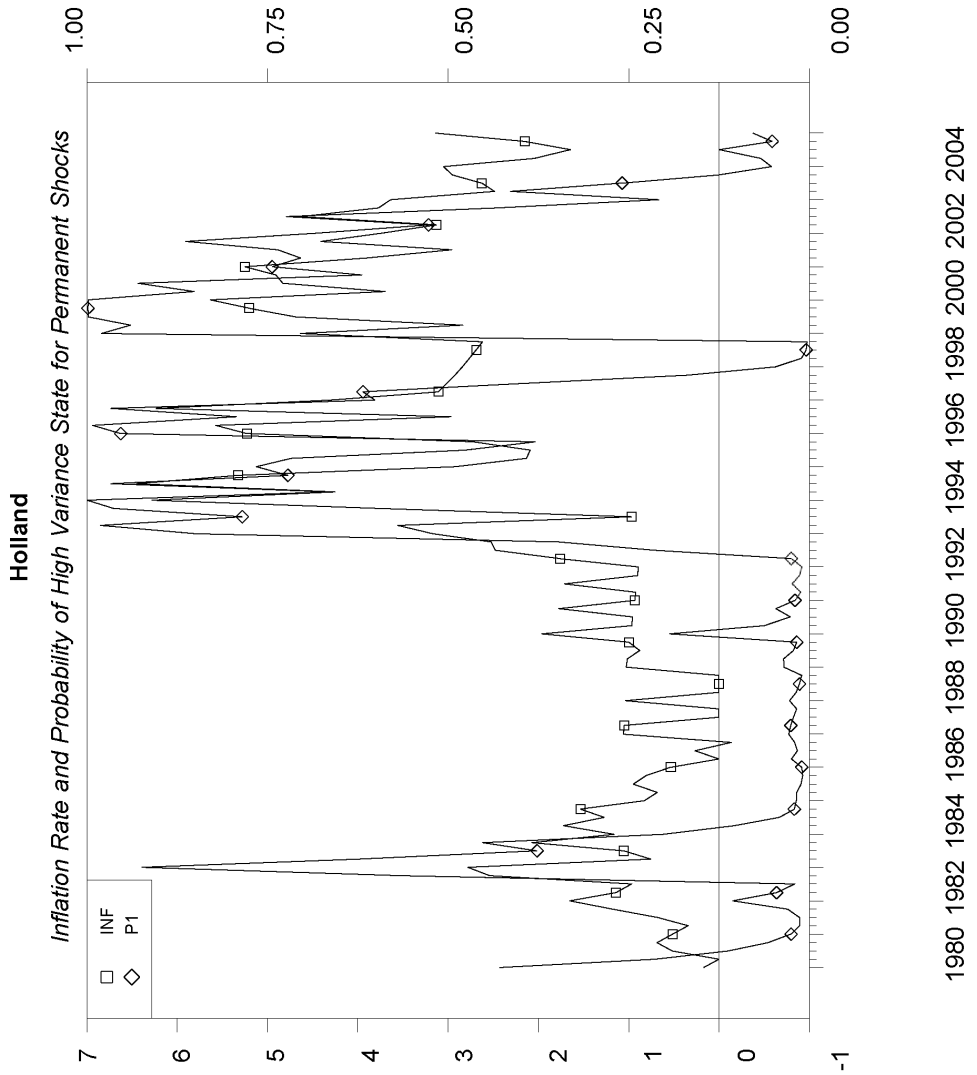
Holland
Inflation Rate and Probability of High Variance State for Permanent Shocks
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P1
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0.50
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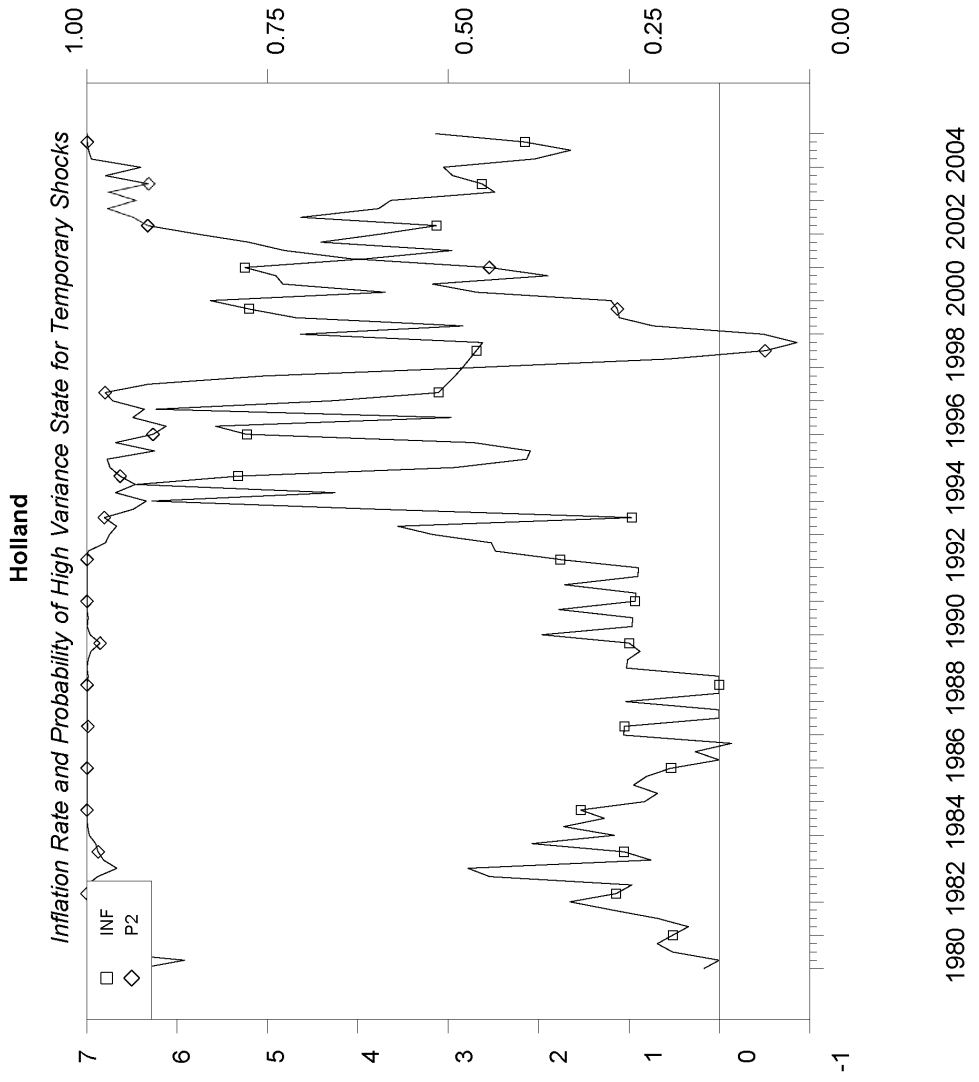
0.00
1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004


Holland
Inflation Rate and Probability of High Variance State for Temporary Shocks
INF
P2
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-1
1.00
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1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004

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THE ECONOMICS OF NEW ENTERPRISES, THE NUMBER OF BUSINESSES AND ECONOMIC GROWTH ACROSS THE EU DURING 2008-2017

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Abstract
The paper looks into five measures of entrepreneurship – namely, the birth rate of enterprises, the death rate of enterprises, the number of 3-year-old enterprises, the employment share of five-year-old enterprises, the average size of five-year-old enterprises- across the European Union from 2008 to 2017. The paper also econometrically analyses growth rates in the number of businesses and the Gross Domestic Product in each EU member-state in the 2008-2017 period and compares their long-run trends. Having noted a good number of similarities it makes a number of potentially useful recommendations on the basis of findings emanating from the birth and death rates of enterprises and other statistics in order to enhance business participation (hence, competition) and economic performance across the EU and beyond.

JEL Classification: A10, C10, C32, C40, E30, M20
Keywords: New Enterprises, Business Population Growth, GDP Growth, European Union.

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Section 1. Introduction

The paper looks into key-aspects of entrepreneurship in the secondary and tertiary sectors (excluding activities of holding companies) across the European Union (EU). Conceptually, entrepreneurship is the activity of successfully executing an idea, i.e., of developing, organizing, and running an enterprise -in the context of this paper: a business idea and business enterprise- by bringing together the necessary agents or factors, and overcoming uncertainties and difficulties. Entrepreneurship, along with the function and the economics of new enterprises (their theory, their measurement, their quantifiable data) constitute an important subject in international literature: a literature running from Schumpeter (1934) to Wong *et al.* (2005), Acs and Szerb (2007), Bosna *et al.* (2020), and others. Acknowledging the role of new businesses in (a) serving and promoting the interests of an individual entrepreneur, and (b) creating and adding value for society, the author's intent is to supply some insights, and provide fellow students with useful information on the prospect of starting their own businesses.

Methodologically, the paper adopts a quantitative, empirical research, approach, and in the pages that follow: (i) Section 2 uses indices to study via indices the evolution of business births, deaths, survival, size and employment in 27 of the 28 EU member-states in the 2008-2017 period (roughly from the time the international and economic crisis reached Europe to the time Brexit negotiations commenced), based on annual figures provided by Eurostat (ec.europa.eu/Eurostat; there are no data on Greece). (ii) Section 3 econometrically analyzes the annual growth rates of Gross Domestic Product (GDP) and of the number of enterprises (companies), based on annual figures provided by Eurostat for each and every member state. (iii) Section 4 provides the conclusions.

Section 2. Business births, deaths, survival, size and employment

We commence by looking into the Birth and Death Rates of businesses. These are defined as follows:

$$\text{Birth Rate} = \frac{\text{number of enterprise births in the reference year (t)}}{\text{number of active enterprises in the reference year (t)}},$$

$$\text{Death Rate} = \frac{\text{number of enterprise deaths in the reference year (t)}}{\text{number of active enterprises in the reference year (t)}},$$

and they are rendered comparable via a Min-Max normalization procedure on a zero-to-ten scale. It goes as follows: Regions, *i*, with extreme values (outliers) below the 4th percentile and above the 96th percentile are assigned scores of zero and ten, respectively, and all other regions are assigned a score of $\hat{x}_i$ or $\check{x}_i$:

To facilitate comparisons across space (states) and time, values are normalized on the zero-to-ten scale via the Min-Max procedure proposed by OECD (2018). It goes

as follows: Member states, *i*, with extreme values (outliers) below the 4th percentile and above the 96th percentile are assigned scores of zero and ten, respectively; and all other regions are assigned a score of $\hat{x}_i$ or $\check{x}_i$:

$$\hat{x}_i = \frac{x_i - \min(x)}{\max(x) - \min(x)} \times 10 \quad (1)$$

$$\check{x}_i = \frac{\max(x) - x_i}{\max(x) - \min(x)} \times 10 \quad (2)$$

when higher and lower values, respectively, relate to the situation desired:

Table 1. The average birth rate and death rate indices in the 27 EU member states, 2008-17

	Countries	Average BRI (2008-2012)	Average DRI (2008-2012)	Average BRI (2013-2017)	Average DRI (2013-2017)
1	Austria	2.478	7.527	0.581	8.229
2	Belgium	1.339	9.978	0.009	9.996
3	Bulgaria	7.099	4.705	5.217	2.822
4	Croatia	2.690	3.694	2.239	5.535
5	Cyprus	0.136	7.457	1.615	7.459
6	Czech Republic	3.434	5.849	2.131	5.897
7	Denmark	4.673	4.011	4.276	3.576
8	Estonia	5.946	4.361	4.173	5.848
9	Finland	3.681	6.746	1.035	7.491
10	France	4.974	7.290	3.105	8.963
11	Germany	2.966	6.009	0.631	6.209
12	Hungary	3.700	4.041	4.116	4.509
13	Rep. of Ireland	1.316	5.231	1.055	8.121
14	Italy	1.750	7.428	0.864	6.706
15	Latvia	8.699	2.804	8.162	4.688
16	Lithuania	9.491	0.372	10.000	0.012
17	Luxembourg	3.703	6.824	2.868	6.440
18	Malta	1.004	7.238	3.857	6.351
19	Netherlands	5.012	6.489	3.164	7.556
20	Poland	6.020	4.582	5.474	3.745
21	Portugal	6.003	0.700	8.232	0.578
22	Romania	5.192	1.650	4.983	4.773
23	Slovakia	6.931	4.636	6.377	3.558
24	Slovenia	4.537	6.472	4.415	5.888
25	Spain	2.349	5.393	2.695	5.544
26	Sweden	2.067	7.824	0.612	8.047
27	United Kingdom	5.019	3.849	7.454	3.560
	Average	4.156	5.302	3.679	5.633

Source: Eurostat, author's own calculations.

Table 1 supplies the Birth Rate Index (BRI) and the Death Rate Index (DRI) for the first and second half of the period studied. These values suggest that over time three countries (namely, Cyprus, Hungary, Spain) improved their relative rankings in both measures (Cyprus, marginally in terms of DRI), four countries (Lithuania, Malta, Portugal, the United Kingdom) improved their relative BRI rankings, thirteen countries (namely, Austria, Belgium, Croatia, Estonia, Finland, France, Germany, the Rep. of Ireland, Latvia, the Netherlands, Romania, Sweden and, marginally, Czech Republic) improved their relative DRI rankings, while the rest (Bulgaria, Denmark, Italy, Luxembourg, Poland, Slovakia, Slovenia) deteriorated in both. Perhaps the practices and policies employed in the cases of improvement (type A countries) should be considered by the rest, and the practices and policies employed in the cases of deterioration should be modified or abandoned.

Next, we consider the Survival Rate of 3-year-old enterprises, which is defined as follows:

$$Survival\ Rate = \frac{number\ of\ enterprises\ in\ the\ reference\ period\ (t)\ born\ in\ t-3\ and\ surving\ to\ t}{number\ of\ enterprise\ births\ in\ t-3}$$

Table 2 supplies the Survival Rates (SR) for the entire period, and the Survival Rate Index (SRI) for the first and second half of the period. SR values reveal that in 26 of the 27 EU member-states more than half of new businesses survived three years later – quite an encouraging statistical finding for those contemplating to engage is such an activity, esp. in Malta, Belgium, Sweden, and the Republic of Ireland, where more than 70% of new businesses survived. (Malta's statistics date to the second half of the periods under consideration.) At the same time, SRI values calculated via expression (1), suggest that over time two countries (namely, the Rep. of Irel-and and Slovakia) improved their relative rankings. So, perhaps the practices and policies employed in the Republic of Ireland, Belgium and Sweden in the first half of the period, and in Malta and Slovakia in the second half of the period, should be considered by the rest.

We also turn to the Employment Share (ES) and mean Size in terms of Employees (SE) of five year-old enterprises, which are defined, respectively, as follows:

$$\text{Employment Share of } 5-\text{year}-\text{old enterprises} = \frac{\text{number of persons employed in enterprises born in year t} - 5 \text{ and surviving to t}}{\text{number of persons employed in enterprises which are active in t}}$$

$$\text{mean Size of five}-\text{year}-\text{old Enterprises} = \frac{\text{number of persons employed in year t among enterprises born 5 years earlier}}{\text{number of enterprises in t born 5 years earlier(i. e., in year t} - 5) \text{ that survived to t}}$$

Table 2. The average survival rate and its index in the 27 EU member states, 2008-17

	Countries	Average SR (%)	Average SRI (2008-2012)	Average SRI (2013-2017)
1	Austria	68.23	8.567	5.192
2	Belgium	81.89	10.000	6.997
3	Bulgaria	57.60	4.822	3.765
4	Croatia	64.56	-	5.220
5	Cyprus	63.39	6.464	4.921
6	Czech Republic	57.67	4.829	3.788
7	Denmark	51.32	3.619	2.155
8	Estonia	58.75	5.020	4.088
9	Finland	58.67	6.075	2.945
10	France	61.57	6.585	3.997
11	Germany	51.47	3.348	2.377
12	Hungary	51.71	3.205	2.597
13	Rep. of Ireland	73.44	6.954	10.000
14	Italy	59.15	6.208	3.283
15	Latvia	54.75	3.646	3.523
16	Lithuania	35.74	0.351	0.112
17	Luxembourg	68.49	7.781	5.950
18	Malta	96.51	-	8.141
19	Netherlands	65.68	6.314	5.967
20	Poland	54.90	4.580	2.817
21	Portugal	40.50	0.653	0.424
22	Romania	65.58	7.362	4.913
23	Slovakia	54.36	3.205	3.721
24	Slovenia	66.29	7.889	4.928
25	Spain	54.60	4.413	2.829
26	Sweden	76.06	9.781	7.516
27	United Kingdom	58.51	4.869	4.110
	Average		5.462	4.306

Source: See Table 1

Table 3 supplies the average SR and SE values for the whole period. The values of the former reveal that in 19 of the 27 EU member-states more that 2% of the people employed in the private sector were employed in enterprises that had commenced operation only five years earlier. (In Bulgaria, the figure exceeded 5% and in six other eastern EU member-states, namely, Croatia, Latvia, Lithuania, Poland, Romania, Slovakia, the figure was between 3% and 4%). Furthermore, avarage SE values reveal that in 12 out of 27 EU member-states, on average, five-year-old enterprises had about 3-6 employees. This suggests that, by and large, they were very small-sized (micro) businesses in terms of EU-28 standards (see Table 4).

Table 3. The employment share and size in terms of persons employed of five-year-old enterprises in the 27 EU member states, 2008-1

	Countries	Average ES (%)	Average SE (people)		Countries	Average ES (%)	Average SE (people)
1	Austria	1.82	3.20	15	Latvia	3.07	4.80
2	Belgium	2.17	2.51	16	Lithuania	3.22	5.39
3	Bulgaria	5.07	5.14	17	Luxembourg	1.89	4.35
4	Croatia	3.18	5.58	18	Malta	2.86	2.91
5	Cyprus	1.62	4.01	19	Netherlands	2.35	2.56
6	Czech Rep.	2.43	2.67	20	Poland	3.19	3.21
7	Denmark	1.66	2.52	21	Portugal	2.62	2.58
8	Estonia	2.42	2.96	22	Romania	3.85	5.12
9	Finland	1.36	1.90	23	Slovakia	3.49	3.02
10	France	2.26	2.81	24	Slovenia	2.16	2.33
11	Germany	1.20	3.00	25	Spain	2.32	2.45
12	Hungary	2.65	3.38	26	Sweden	1.70	1.88
13	Rep. of Ireland	1.74	2.74	27	United Kingdom	2.32	4.52
14	Italy	2.20	2.53				

Source: See Table 1.

Table 4. Classification of businesses, EE-28

	Staff headcount and (a) Turnover or (b) Balance sheet total (in million euro)		
Micro	< 10	≤ 2	≤ 2
Small	< 50	≤ 10	≤ 10
Medium-sized	< 250	≤ 50	≤ 43
Large	≥ 250	> 50	> 43

Source: EU recommendation 2003/361(2003).

Section 3. Growth in the number of businesses and in GDP

We shift our attention to the study of growth patterns of business numbers and GDP across EU member-states as reported by Eurostat, by econometrically isolating autonomous (initial) components, time trends and notable medium-term (biennial or longer) fluctuations of the trends. To that end we employ a close variant of the well-established functional form described by Smith and Duncan (1944), Fox (1968), Franzini and Harvey (1983), Black (1992), Cameron (2005), Lee *et al.* (2019) and others:

$$y_{tc} = \beta_{0c} + \beta_{1c}\, t_i + \beta_{2c}\, t_i^2 + \sum_{i=0}^{3} \beta_{3ic}\, m_{itc}, \quad (3)$$

where 'y' stands for the regressand. Each equation is regressed via STATA 2013 separately, i.e., not as a system, and each regression involves annual data from all 28 EU member-states. 't' stands for time (t=1, …, 10) and enters the expression both as an index and as the long-run trend variable in each member-state. The trend may be linear; however, the inclusion of its square allows for the consideration of non-linear features (including a peak or a trough). 'c' stands for the number of member-states. 'm' is in binary form and stands for an exceptionally high medium-term deviation or fluctuation from the trend observed in a member-state. 'i's denote the number of these medium-term deviations in a member-state ($i \in [0,2]$ in the sense that ultimately, the maximum number of such fluctuations in any one state is two; however, in most states it is equal to 0). 'β's stand for the regressors' coefficients. Germany is set as reference, and in order to deal with heteroscedastic residuals both regressions are conducted with robust standard errors. The results are provided in Tables 5 and 6.

The former suggests that at the outset Lithuania (line 2), Estonia, Cyprus, Malta, the United Kingdom (line 3) featured the highest negative rates of change in the number of enterprises, while Greece (line 6) featured the highest positive rate. Subsequently (over time), rates:

- grew negative in Austria, the Netherlands, Poland (line 9), Bulgaria, Czech Republic, Romania, Slovenia, Sweden (line 10) and, probably, in Finland, France, Germany, Italy, Luxembourg, Slovakia (line 11; the p-values are quite modest);
- grew positive in Cyprus, Malta (line 13), Croatia, Denmark, Hungary and Spain (line 12);
- first decreased and then increased in Greece (lines 7 and 20, featuring a minimum in the 8-9 year), Belgium (lines 8 and 19, min 6-7 year), Portugal and the Republic of Ireland (lines 9 and 19, min 3-4 year), as per the twice differentiable function with respect to time (the estimated minima are provided in Table 7, column (2));
- first increased then decreased in Lithuania (lines 15-16, max 7-9 year), Latvia (lines 14 and 17, max 5-6 year), Estonia and the United Kingdom (lines 14 and 18, max 8-9 year).

In addition they featured large positive fluctuations from the trend in Lithuania during 2011-12 (line 23) and the Netherlands during 2015-16 (line 26), and large negative fluctuations from the trend in Romania during 2009-10 (line 21), Portugal during 2009-13 (line 22), the Czech Republic and Slovakia during 2012-13 (lines 24-25).

The findings of Table 6 suggest that at the outset Croatia, Estonia, Finland, Hungary, Italy, Latvia, Luxembourg, the Republic of Ireland, Slovenia (line 2) featured the highest negative GDP rates while Cyprus and Poland (line 6) featured the highest positive rates. Subsequently, the rates:

- grew positive in Luxembourg, Malta, the Republic of Ireland (line 12), Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Romania, Slovenia, the

United Kingdom (line 11), Bulgaria, Denmark, Finland, Italy, Sweden (line 10), Austria, Belgium, France, Netherlands (line 9), and, possibly, in Germany and Slovakia (line 8); probably grew negative in Spain (line 7);

- probably grew negative in Spain (line 7);
- first decreased and then increased in Cyprus, Greece (lines 5 and 14, min 4-5 year), Poland and Portugal (lines 6 and 13, min 4-5 year).

Table 5. The growth of the (net) number of businesses in the 28 EU member states, 2008-17

	Independent variables	coefficients	p-values
	Autonomous components		
1	Constant (Finland, Germany, Italy, Portugal, Rep. of Ireland serve as reference)	1.3102	0.1300
2	Lithuania	-30.7751	0.0000
3	Cyprus, Estonia, Malta, United Kingdom	-11.2811	0.0000
4	Croatia, Denmark, Hungary, Latvia, Spain	-4.8308	0.0000
5	Austria, Belgium, Bulgaria, Czech Republic, France, Luxembourg, Netherlands, Poland, Romania, Slovakia, Slovenia, Sweden	4.5468	0.0000
6	Greece	53.6699	0.0000
	Time trend		
7	Greece	-13.6950	0.0000
8	Belgium	-1.3596	0.0000
9	Austria, Netherlands, Poland, Portugal, Rep. of Ireland	-0.7330	0.0000
10	Bulgaria, Czech Republic, Romania, Slovenia, Sweden	-0.4423	0.0000
11	Finland, France, Germany, Italy, Luxembourg, Slovakia	-0.1800	0.1920
12	Croatia, Denmark, Hungary, Spain	0.5317	0.0000
13	Cyprus, Malta	1.6619	0.0000
14	Estonia, Latvia, United Kingdom	3.5265	0.0000
15	Lithuania	10.6204	0.0000
	Time trend squared (to capture the rate of change)		
16	Lithuania	-0.7410	0.0000
17	Latvia	-0.3104	0.0000
18	Estonia, United Kingdom	-0.2151	0.0000
19	Belgium, Portugal, Rep. of Ireland	0.1070	0.0000
20	Greece	0.8250	0.0000
	Notable biennial or longer fluctuations		
21	Romania 2009-10	-10.9913	0.0000
22	Portugal 2009-13	-4.0952	0.0000
23	Lithuania 2011-12	8.6281	0.0000
24	Czech Republic 2012-13	-4.5045	0.0000
25	Slovakia 2012-13	-7.6221	0.0000
26	Netherlands 2015-16	4.1212	0.0000
	Observations	241	
	Model fitness (R^2)	46.45%	

Note: Regressions are estimated with robust standard errors so as to address issues of heterogeneity and lack of normality.

Source: See Table 1.

In addition, they featured large positive fluctuations from the trend in France, Finland and Sweden during 2010-11 (lines 18-19), Estonia during 2010-13 (line 20), Latvia during 2011-12 (line 21), and Greece during 2013-15 (line 25), and large negative fluctuations from the trend in the Republic of Ireland during 2008-09 and 2012-13 (lines 15 and 22), Latvia and Romania during 2009-10 (lines 16-17), the Czech Republic during 2012-13 (line 23), Cyprus during 2012-14 (line 24), Luxemburg, Malta, and the United Kingdom during 2016-17 (lines 26-28).

Table 6. The growth of real GDP in the 28 EU member states, 2008-17

	Independent variables	coefficients	p-values
	Autonomous effects		
1	Constant (Austria, Belgium, Bulgaria, Czech Republic, Denmark, France, Germany, Greece, Lithuania, Malta, Netherlands, Romania, Spain, Sweden, United Kingdom serve as reference)	-1.3285	0.0340
2	Croatia, Estonia, Finland, Hungary, Italy, Latvia, Luxembourg, Rep. of Ireland, Slovenia	-1.9125	0.0000
3	Portugal, Slovakia	2.9315	0.0030
4	Cyprus, Poland	6.0809	0.0000
	Time trend		
5	Cyprus, Greece	-2.2613	0.0000
6	Poland, Portugal	-1.0312	0.0060
7	Spain	-0.5172	0.1100
8	Germany, Slovakia	0.1133	0.3110
9	Austria, Belgium, France, Netherlands	0.3668	0.0000
10	Bulgaria, Denmark, Finland, Italy, Sweden	0.4719	0.0000
11	Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Romania, Slovenia, United Kingdom	0.6674	0.0000
12	Luxembourg, Malta, Rep. of Ireland	1.3507	0.0000
	Time trend squared (to capture the rate of change)		
13	Poland, Portugal, Spain	0.1110	0.0010
14	Cyprus, Greece	0.2512	0.0000
	Notable biennial or longer fluctuations		
15	Rep. of Ireland 2008-09	-3.5849	0.0000
16	Latvia 2009-10	-7.7775	0.0230
17	Romania 2009-10	-5.0400	0.0000
18	France 2010-11	2.0949	0.0000
19	Finland, Sweden 2010-11	4.3832	0.0000
20	Estonia 2010-13	4.9714	0.0000
21	Latvia 2011-12	5.4377	0.0000
22	Rep. of Ireland 2012-13	-3.3876	0.0100
23	Czech Republic 2012-13	-2.9923	0.0000

24	Cyprus 2012-14	-4.3606	0.0010
25	Greece 2013-15	3.7165	0.0010
26	Luxembourg 2016-17	-6.3903	0.0200
27	Malta 2016-17	-5.3528	0.0150
28	United Kingdom 2016-17	-3.1119	0.0000
	Observations	279	
	Model fitness (R^2)	52.59%	

Note and Source: See Table 5.

Section 4. Conclusions

It turns out that during 2008-17, in 17 of the 28 EU states (Bulgaria, Croatia, the Czech Republic, Denmark, Hungary, Lithuania, Malta, Romania, Sweden, Slovenia, Finland, France, Germany, Italy, Luxembourg, Slovakia, Portugal) the long-term trends of the two measures were similar. Understandably, the GDP is also affected by other factors (esp. in the other member-states). In two of the 17 states and in two of the other states more than 70% of new businesses survived three years later, and in four of the former and three of the latter, businesses born five years earlier employed more than 3% of all employees in the private sector. In all states, by and large, new companies employed a small number of staff throughout this period. If the practices and policies employed in type A countries, esp. the Rep. of Ireland, and Belgium-Sweden in the first half of the period, and Malta-Slovakia in the second half of the period, were employed by the rest, perhaps even more businesses might have survived.

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