EKONOMICKÉ ROZHĽADY – ECONOMIC REVIEW, 2022, 51(3), 278 ─ 296
https://doi.org/10.53465/ER.2644-7185.2022.3.278-296

CHANGES IN THE SECTORAL STRUCTURES OF THE ECONOMY AND THE STOCK MARKET AND THE IMPACT OF THE COVID-19 PANDEMIC ON ACCELERATING THESE PROCESSES

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Abstract: *The arrival of Industry 4.0 has brought to the forefront the demand for changes in the structure of the economy measured by GDP. This trend is being picked up more quickly by the stock market, which also signals how and where the economy should go in the future. The arrival of the Covid 19 pandemic also showed the need for restructuring of economies with the use of inteneration, digitization and robotization, which will bring stability to the economy even in times of negative development or stronger economic growth. These changes have been implemented in the last decade in several, especially developed, countries of the world. The aim of this paper is to show the extent to which countries with a small economic dimension within the EU, such as Finland, Ireland, Austria and the Czech Republic, are able to implement these processes. The aim is to quantify in detail the sectoral structure of GDP and the relevant stock indices, especially with regard to the current situation caused by the Covid-19 pandemic.*

Keywords: *sectors of GDP, structure of stock index, new technologies, Industry 4.0, internetization of economy*

JEL Classification: G12, G19, E00, O31

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1 Introduction

In the last century, there has been considerable symbiosis in the development of the stock market and the real economy. It has often been said that the stock market is a mirror of the economy. Significant changes and 'the scissors effect' between the development of the economy and the stock market began to manifest itself mainly at the beginning of this century and the bursting of the so-called technological bubble in the stock market as a result of a significant diversion of the stock market from the economy. Subsequent developments have shown another major discrepancy between economic and stock market developments. In the previous decades stock markets of developed countries showed a tendency of so-called financialization of the economy. This could be observed in stock markets where sectors of financial services showed enormous increase. This trend was also reflected in a significant change in the sectoral structure of the economy where the share of financial services in GDP increased as well. After the financial crisis which has caused a huge fall in the equity markets, in particular in the financial services sector, emerged also a change in the attitude of investors in the equity markets. Investors have started to pay particular attention to the latest technology which underlies the current structural changes within each economy.

The advent of the fourth stage of the industrial revolution named Industry 4.0 is associated with the demand mainly for the growth of labor productivity but also for changes in the nature of work brought by robotization and digitalization of the whole economy. The demand for accelerating the restructuring of economies of the developed countries also stemmed from the fact that in previous years there was a significant slowdown in GDP growth even in the most developed countries, and some even stagnated. This fact further highlighted the onset of a new crisis associated with the global Covid-19 pandemic, which brought significant downturns not only to economies but also to stock markets. Nevertheless, it can be stated that the stock market has started to grow again in a relatively short period of time and signals demands for accelerating economic restructuring.

Today the stock market is reacting to these changes in advance and its massive investments in the new technology-related companies should also support the real economy in a short time. It can also be stated that such a restructured economy would be able to withstand more pitfalls, such as the global coronavirus pandemic.

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The most important world equity markets including those in the USA, Japan and Germany have been signaling significant changes in the structure of stock indices in accordance with Industry 4.0 requirements in recent years. These changes should also be supported by a faster process of restructuring of the real economy which would also ultimately lead to a change in the structure of the GDP indicators. To what extent can countries with small economic space such as Finland, Ireland, Austria or the Czech Republic respond to these necessary processes are addressed in this paper.

The choice of these four countries was mainly influenced by their similar size, similarly developed economies and stock markets. At the same time, they also show great potential for the future. They are characterized by technological innovations, startups and their support. In this area, they are among the top 20 countries in the world ranking. Therefore, in our article, we focus on the potential of these countries to implement Industry 4.0 and whether they have been able to change the structure of stock indices in connection with the requirements of this industrial revolution or whether they will be able to do so in the future.

2 Literature Review

The current economic theory pays great attention to the relationship between the economy, the GDP indicator and the stock market. Research in this area addresses, in particular, the extent to which the stock market promotes economic growth as described by Desmet and Parente (2012) and Cornell (2010).
Some studies directly apply this relationship to selected countries of the world such as the BRICS which have experienced significant economic growth in the past and they also have large local stock markets compared to the global stock markets. For a more detailed view of the BRICS countries, consult Yu(2011), and Osaseri and Osamwoney (2019) who demonstrate the positive impact of the stock market on the economies of these countries.

Particular attention is also drawn to the relatively extensive research from Siegel (1991), where the author also pointed out to another connection between the stock market and the economic cycle. His research proved that the stock market in the economic cycle can predict the future onset of recession and thus a decline in GDP. Laurence (2010) reached similar conclusions in his research.

While previous authors examined the relationship of GDP and the stock market from a macroeconomic point of view, an increasingly large group of authors, especially after the financial crisis, began to study the internal structure of GDP and the stock market composition monitored by stock indices. This stems from the need to realize structural changes in the economies of individual countries, which clearly requires also the onset of the fourth stage of the industrial revolution. More detailed research on the structure of GDP indicators and stock indices can be found in Roll (1992), Chan, Lakonishok and Swaminathan (2007), Yevsikov, Korovin and Sarygulov (2017). To what extent the stock market is currently revealing the real economy is researched in detail also by Swinkels and Xu (2017). The mentioned studies suggest that the stock market largely fulfills a signaling function for the economy. Investors are investing in the stock markets in advance in those sectors that could in the future significantly affect the development of the economy.

Ilyina and Samaniego (2011) and Brown, Fazzari and Petersen (2013) are looking at the need for change and, in particular, innovation in the financial sector. Qamruzzaman and Wei (2018) also deal with the relationship between stock market innovation and economic growth.

In connection with the onset of Industry 4.0, the scientific articles by Crjac, Tower and Banduka (2017) as well as Lafferty (2019) are focused on various aspects of these processes and concentrate attention on new forms of business models are increasingly emerging. These new strategies will make possible to implement the outputs of the fourth industrial revolution into practice. Adamovský and Gonda (2019) identify the innovation efficiency of Slovakia and other European countries and draw attention to the need to improve technological efficiency in some countries including Slovakia. Other authors examine the positive and negative impacts as well, but what is apparent is the need for changes in the economic structures of the countries.

The onset of Industry 4.0 and the need for accelerated restructuring of economies is also developing the debate on the need for greater use of venture capital in this process. The possibility of financing start-up companies, which significantly contribute to the implementation of the requirements of the industrial revolution, is coming to the fore too. Samila and Sorenson (2011) as well as Popov (2014) draw attention to this area in their research. Venture capital and start-up companies are now part of sectors that have a dominant position in the stock markets, especially in developed economies.

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The authors Rossi and Gunardi (2018) tried to analyze the ideas of the theory of market efficiency with a special emphasis on the stock markets of selected European countries and the more specific impact of monetary indicators such as long-term interest rates and the impact of inflation on the GDP of mainly small open economies is also investigated by Wesolowski (2018).

The authors Rostoka, Locovs and Gaile-Sarkane (2019), for instance, pay considerable attention to the long-term effective cooperation of university workplaces in the field of research with private companies.

The links between growth, GDP change and the stock market and future changes in these relations have been particularly acute during the onset of the Covid-19. Other authors Hong Bian and Lee (2021) point out that even advanced stock markets behaved inefficiently during the pandemic and that their growth was marked by considerable speculation. Maarten de Vet et al. (2021) in their study for the EU Parliament analyze the effects of the EU pandemic, especially on industry, and point to the need for major changes in the economy, mainly related to digitization processes. They also emphasize that the launch of the Covid-19 pandemic has acted as an accelerator of digitization.

3 Aim and Methodology

Nowadays the stock indicators of developed countries signal changes in the sectoral structure, which will also have an impact on changes in the GDP structure. The extent to which countries with a small economic dimension can trigger these changes is also part of the analysis of this research. The aim of this paper is to examine in detail the sectoral structure of the economy and its stock market indicators, to identify weaknesses from the perspective of the future development of the economies and to find their interconnection with the requirements of the present. The subject of our research are the countries of the European Union such as Finland, Ireland, Austria and the Czech Republic, where we assume greater scientific and technological potential and capital, which will also trigger the expected changes.

The article is meant to verify the following two hypotheses as a part of outlined issues:

- *Hypothesis 1:* Sector structures of stock indices and GDP composition differ considerably across the countries under review.
- *Hypothesis 2:* The stock market does not fulfill the signaling function for every economy.

When processing this issue, in addition to the usual scientific research methods, the quantitative method of regression analysis and correlation are also used. The equation used in the linear regression model where the stock index is the dependent variable, β_0 is intercept vector of unknown parameters, β_1 is slope coefficient corresponding to the regressor, GDP is the independent variable and ε_i are unobserved scalar random variables (errors).

$$Index_i = \beta_0 + \beta_1 GDP_i + \varepsilon_i \quad (1)$$

Pearson's correlation coefficient, when applied to a sample is commonly represented by the formula below that can be obtained by substituting estimates of the covariances and variances where n is a sample size, x and y are the individual sample points. The correlation mathematical equation - Pearson's correlation coefficient:

$$r_{xy} = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}} \quad (2)$$

In researching this issue we used the data from Bloomberg for stock indices related data, Eurostat for GDP related data including GDP sector structure and MSCI for stock indices sector data. In addition to that we also used information from the Eurostat database, the European Central Bank and national statistics. Individual national indices of selected countries were used to monitor the development of stock markets: Ireland and its ISEQ stock index, Finland - OMX stock index, Austria - ATX stock index and PX stock index for the Czech Republic.

4 Results

In the previous decade, the stock markets of Finland, Ireland, Austria and the Czech Republic showed an increase similar to that of the major world economies. We can also observe this development on the following graph. However, we must state that the greatest dynamic development was recorded by the Irish stock index, where a more significant decline was manifested

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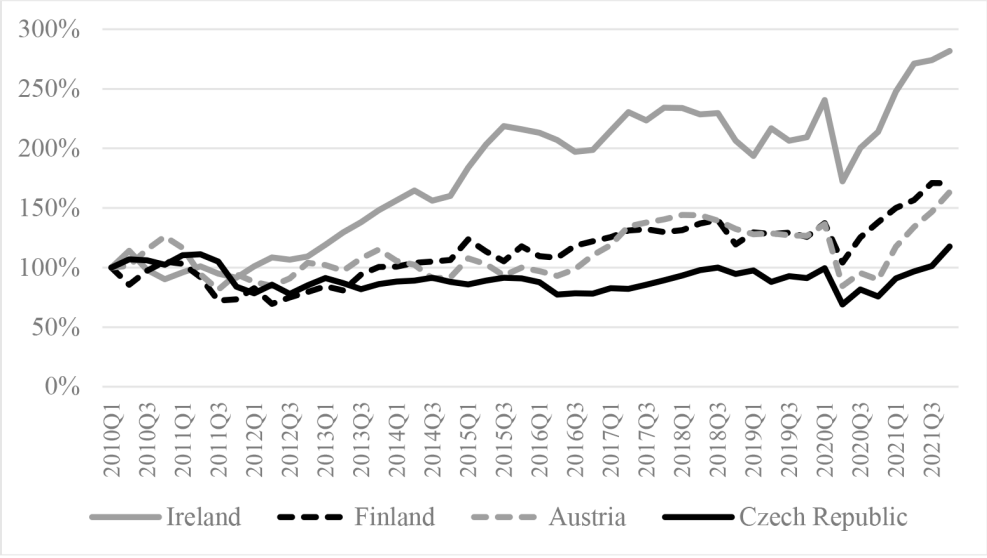
mainly at the time of the outbreak of the pandemic. The Finnish index had lower growth rates.

Figure 1: Stock indices performance in selected countries (from Q1 2010 to Q4 2021)



Source: own processing according to: www.tradingeconomics.com

The Finnish index had a similar trajectory, but with lower growth rates. On the contrary, the stock indices of Austria and the Czech Republic recorded lower growth rates with a slight decrease during the pandemic. To what extent the stock market of these countries contributed to changing the structure of the economy in terms of the requirements of Industry 4.0, whether there was also a change in the sectoral structure that would significantly contribute to structural changes in the economy, we will try to analyze in the following interpretation.

The first phase of the research was focused on the more detailed sectoral structure of the stock indices of the selected four countries. It is assumed that the onset of Industry 4.0 requires that stock indices also respond to these processes and will also signal the need for structural changes in the economy. For this reason, the sectoral structure of individual stock markets is firstly analyzed and afterwards changes in the structure of GDP.

Table 1: Selected stock indices according to the structure by sectors in 2020

Sector	Ireland ISEQ	Finland OMX	Austria ATX	Czechia PX
Industrials	8.26%	25.59%	10.33%	0.00%
Information Technology	**0.19%**	**19.18%**	**1.67%**	**0.00%**
Materials	28.57%	17.20%	11.20%	0.00%
Financials	7.75%	11.97%	35.50%	52.42%
Communication	**0.00%**	**6.91%**	**2.99%**	**8.23%**
Utilities	0.00%	4.81%	7.03%	39.35%
Energy	0.00%	4.50%	16.65%	0.00%
Health Care	5.56%	2.79%	0.00%	0.00%
Consumer Discretionary	10.71%	3.11%	1.65%	0.00%
Consumer Staples	31.20%	2.97%	0.73%	0.00%
Real Estate	7.76%	0.97%	12.25%	0.00%

Source: own processing according to: www.msci.com/zh/europe

On the basis of the table above it can be concluded that except of Finland the stock market is underrepresented in the sectors of Information Technology and Communication in all other countries. In other words, in Ireland, Austria and the Czech Republic, the stock market does not sufficiently provide a signaling function in favor of the economy. This role is only fulfilled by the stock market in Finland, where the stock market share already exceeds 25%.

For better orientation, in developed countries such as the USA, the share of Information Technology and Communication represents more than 29% in the S&P 500 index in 2020, in the Japanese Nikkei index these sectors account for approximately 23% and in the German DAX index more than 19%. It can be stated that only the Finnish stock market replicates global trends in terms of sectoral exposure of stock indices and fulfills a signaling function in relation to the real economy. The above-mentioned stock indices, mainly the Austrian ATX index and the Czech PX index also show a still high share of financial services, which currently recorded a significant decline in world stock markets. It can be stated that the so-called "financialization" in these markets is still ongoing.

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While analyzing the sectoral structure of GDP, a surprising fact was observed. The significant share of Information Technology and Communication sectors in the stock markets is not sufficiently reflected even in the structure of Finland's real economy where its share in GDP is only 5.4%. On the other hand, in Ireland where a weak stock market signaling was identified the GDP share is 9.4%, that is the highest of the selected countries.

Table 2: Selected gross domestic products according to the structure by sectors in 2020

Sector	Ireland	Finland	Austria	Czechia
Materials	15.2%	14.7%	15.50%	19.80%
Consumer Staples	15.0%	14.5%	18.70%	14.50%
Financials	20.5%	13.3%	15.70%	11.60%
Industrials	16.3%	12.3%	11.50%	14.50%
Public sector	7.5%	12.2%	10.70%	9.70%
Real Estate	4.6%	8.5%	6.40%	5.60%
Health Care	4.3%	7.7%	5.30%	3.50%
Consumer Discretionary	5.2%	6.9%	9.10%	12.10%
Utilities	1.5%	3.5%	2.90%	3.40%
Information Technology	**6.3%**	**3.9%**	**2.50%**	**3.00%**
Communication	**3.1%**	**1.5%**	**1.10%**	**1.30%**
Energy	0.5%	1.0%	0.60%	1.00%

Source: own processing according to: www.ec.europa.eu/eurostat/data

The GDP structure still shows a significant share of financial services, especially in Ireland and Austria. It can be expected that this share in GDP will decrease more significantly in the future assuming the structural changes. From the perspective of the mutual relationship of the stock market and the real economy this was quantified separately for individual countries.

When monitoring the development of GDP and stock indices of these countries in the short term, we can observe more significant differences. The Covid 19 pandemic in 2020 had a more significant impact on GDP declines in Austria and the Czech Republic, with a smaller decline in Finland as well. On the

contrary, the positive development of GDP was reflected in Ireland, which is probably related to a higher degree of digitalization of the economy. Today, information technology together with communications account for around 10% of Ireland's GDP.

Table 3: Development of GDP and stock indices (2015-2020)

	% change	2015	2016	2017	2018	2019	2020
Ireland	GDP	25.2	2	8.9	9	4.9	5.9
	ISEQ	30	-4.04	7.99	-22.14	31.09	2.69
Finland	GDP	0.5	2.8	3.2	1.1	1.3	-2.9
	OMX	12.43	9.55	6.46	-5.94	14.57	8.63
Austria	GDP	1	2	2.4	2.6	1.4	-6.3
	ATX	10.97	9.24	30.62	-19.72	16.07	-12.76
Czechia	GDP	5.4	2.5	5.2	3.2	3	-5.8
	PX	1.02	-3.63	16.99	-8.5	13.08	-7.93

Source: own processing according to: www.tradingeconomics.com

We can observe even more significant changes in the development of stock indices. The Austrian and Czech stock indices saw the largest decline as a result of the pandemic, while the stock market in both Ireland and Finland rose slightly.

In the following text, we will try to analyze the longer-term relationship between the development of the economy through GDP and the stock market in the thirty-year horizon.

Ireland

Ireland stock index (ISEQ) consists of 25 holdings. The index is denominated in euro. The biggest company listed in the index is CRH PLC (Materials sector) followed by Kerry Group (Consumer Staples) and Bank of Ireland Group (Financials). The average P/E ratio is 12.90 and the dividend yield of the index is 1,68% annually.

Looking at the correlation between stock index and GDP development, the stock market in Ireland is to some extent replicating the economy and signaling changes in GDP growth or decline some time in advance. The mentioned

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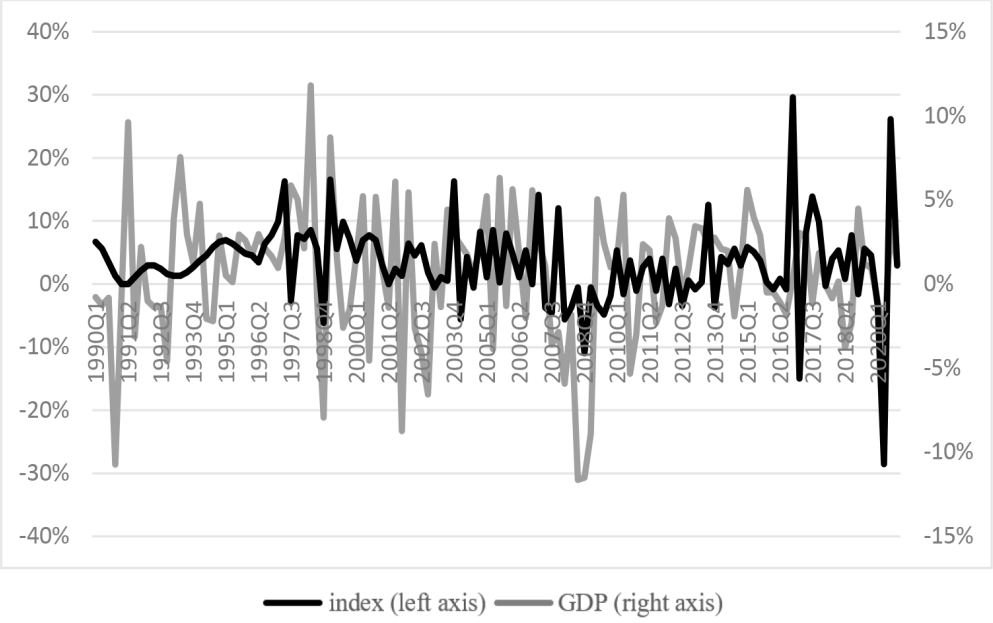
connection can be observed in 2007-2008, but also in 2016-17, which may be directly linked also to Brexit.

Figure 2: Quarterly percentage changes of GDP and stock index in Ireland (1990 – 2020)



Source: own processing according to: www.bloomberg.com

In the next step this relationship is quantified through the OLS model in the long run over the period from 1990 to 2020.

Figure 3: OLS model for Ireland, using observations 1990:1-2020:4 (T = 124)

Dependent variable: *Ireland_index*

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.0050354	0.0115986	0.4341	0.6668	
Ireland_GDP	0.929897	0.471949	1.961	0.0533	*

Mean dependent var	0.016665	S.D. dependent var	0.108832
Sum squared resid	1.317555	S.E. of regression	0.107509
R-squared	0.032930	Adjusted R-squared	0.024450
F(1, 114)	3.882141	P-value(F)	0.051237
Log-likelihood	95.11620	Akaike criterion	−186.238
Schwarz criterion	−180.721	Hannan-Quinn	−183.999
rho	0.046354	Durbin-Watson	1.897413

corr(Ireland_GDP, Ireland_index) = *0.18147277*

Source: own processing in Gretl software

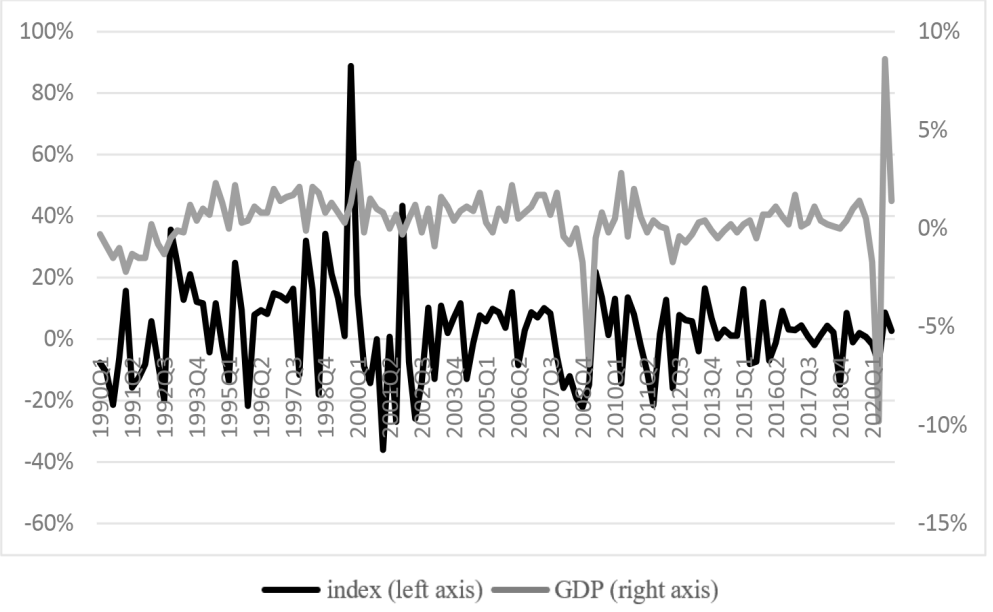
As shown in the above OLS model for Ireland the correlation for GDP-stock market relationship is positive and therefore correct according to economic theory although it is lower that points to weaker relationship.

Finland

Finland stock index (OMX Helsinki) consists as well of 25 holdings. The biggest company listed in the index is Nokia (Information Technology) with 16.31% share in the index followed by Kone (Industrials) and Sampo (Financials). The average P/E ratio is 15.46 and the dividend yield of the index is 4.10% annually.

Observing the development of the stock index and GDP in Finland it can be stated that they mutually interact with each other. With only a small delay the development of the economy follows the stock market. In 1999-2000, the stock index showed a significant increase, which is associated with new technologies (technology bubble), which also supported economic growth. At the time of the financial crisis of 2008-2009, the index recorded a decline but it did not record such significant losses in comparison with other stock markets.

Figure 4: Quarterly percentage changes of GDP and stock index in Finland (1990 – 2020)



Source: own processing according to: www.bloomberg.com

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Figure 5: OLS model for Finland, using observations 1990:1-2020:4 (T = 124)

Dependent variable: *Finland_index*

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.0130970	0.0152907	0.8570	0.3940	
Finland_GDP	3.38863	1.20389	2.817	0.0060	*

Mean dependent var	0.026310	S.D. dependent var	0.161389
Sum squared resid	2.800647	S.E. of regression	0.156741
R-squared	0.064991	Adjusted R-squared	0.056789
F(1, 114)	7.923685	P-value(F)	0.005755
Log-likelihood	51.38013	Akaike criterion	−98.7609
Schwarz criterion	−93.2555	Hannan-Quinn	−96.5247
rho	0.000058	Durbin-Watson	1.988439

corr(Finland_GDP, Finland_index) = *0.25492823*

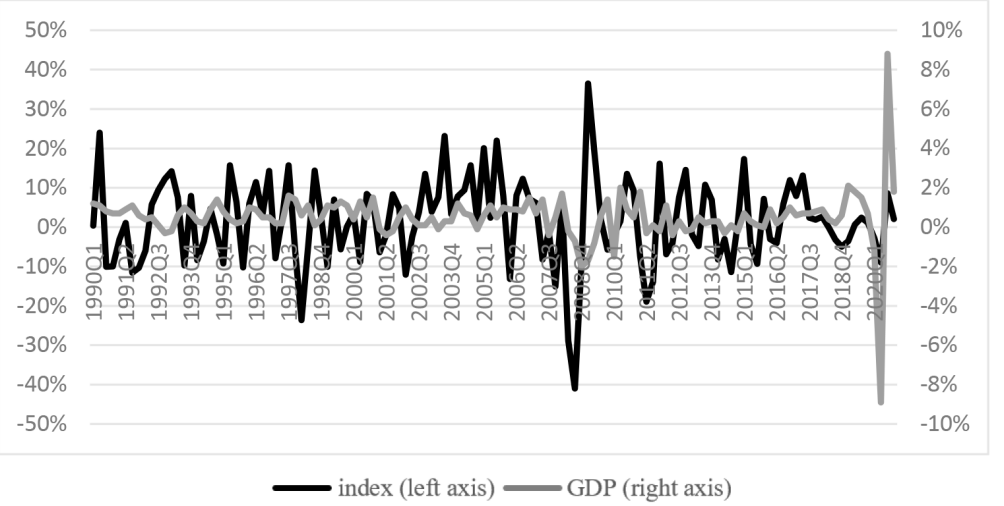
Source: own processing in Gretl software

The OLS model for the years 1990-2020 demonstrates a positive link between the stock market and Finland's GDP. The correlation index is above 0.25, which is higher than in Ireland.

Austria

Austria stock index (ATX) consists of 27 companies. The biggest company listed in the index is Erste Group Bank (Financials) followed by OMV (Energy) and Verbund (Utilities). The average P/E ratio is 10.41 and the dividend yield of the index is 3.99% annually. Financial services have a majority in the index, which was also reflected in a significant decline (40%) during the global financial crisis.

Figure 6: Quarterly percentage changes of GDP and stock index in Austria (1990 – 2020)



Source: own processing according to: www.bloomberg.com/europe

It can also be stated, that the Austrian stock market lacks incentives in the area of new technologies, which from the perspective of the future, create the possibility of further positive economic development.

Figure 7: OLS model for Austria, using observations 1990:1-2020:4 (T = 124)

Dependent variable: *Austria_index*

	Coefficient	*Std. Error*	*t-ratio*	*p-value*
const	0.0181230	0.0130529	1.389	0.1679
Austria_GDP	−0.344127	1.59510	−0.2147	0.8299

Mean dependent var	0.016430	S.D. dependent var	0.111738
Sum squared resid	1.434977	S.E. of regression	0.112186
R-squared	0.000410	Adjusted R-squared	0.008361
F(1, 114)	0.046550	P-value(F)	0.829584
Log-likelihood	90.16494	Akaike criterion	−176.338
Schwarz criterion	−170.829	Hannan-Quinn	−174.093
rho	0.202175	Durbin-Watson	1.593812

corr(Austria_GDP, Austria_index) = *-0.02020210*

Source: own processing in Gretl software

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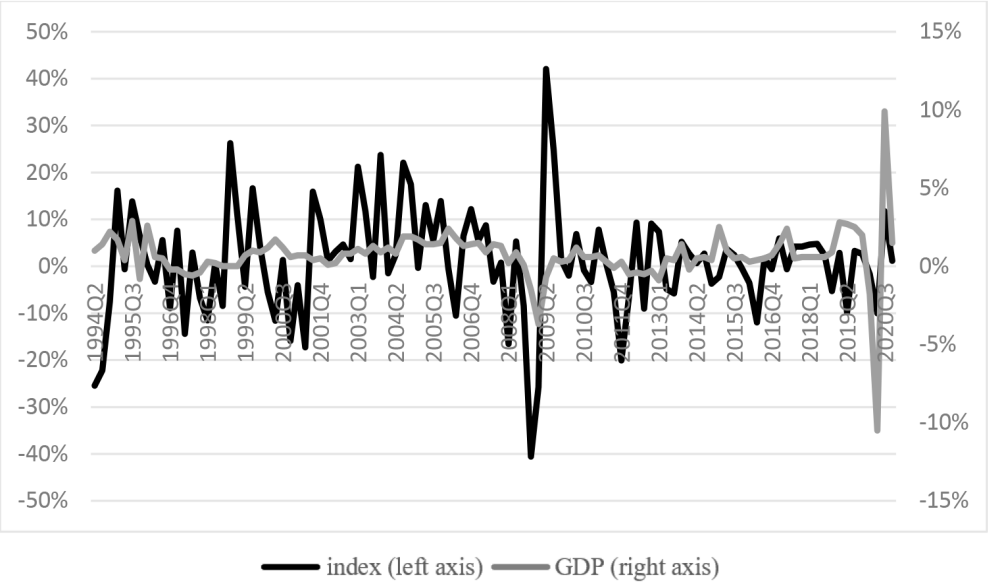
The result in the form of a correlation between GDP and the stock index of -0.02020210 (negative correlation) demonstrates the need for necessary changes in the stock market as well as in the Austrian economy.

Czech Republic

Czech Republic index (PX) consists of 11 companies. The biggest company listed in the index is CEZ (Utilities) followed by Komercni Banka (Financials) and Moneta Money Bank (Financials). The average P/E ratio is 12.30 and the dividend yield of the index is 5.84% annually. Financial services have a majority in the Czech stock market. This was also seen in a deep stock market slump in times of financial crisis (similar to Austria).

Figure 8: Quarterly percentage changes of GDP and stock index in Czechia (1994 – 2020)



Source: own processing according to: www.bloomberg.com

As in the previous three countries, the relationship of GDP and the stock market in the Czech Republic using the OLS model was investigated, based on which could be observed the following results.

Figure 9: OLS model for Czech Republic, using observations 1994:2-2020:4 (T = 107)

Dependent variable: *Czech Republic_index*

	Coefficient	*Std. Error*	*t-ratio*	*p-value*
Const	0.012107	0.020217	0.5993	0.5510
Czech Rep.GDP	1.92048	1.93161	0.9941	0.3223

Mean dependent var	0.023080	S.D. dependent var	0.181536
Sum squared resid	3.725973	S.E. of regression	0.181582
R-squared	0.008675	Adjusted R-squared	0.000110
F(1, 113)	0.988510	P-value(F)	0.322243
Log-likelihood	34.02437	Akaike criterion	−64.0487
Schwarz criterion	−58.5587	Hannan-Quinn	−61.8206

corr(Czech Republic_GDP, CzechRepublic_index) = 0.09312341

Source: own processing in Gretl software

This result also suggests that there is only a weak, albeit positive, correlation (0.09312341) between GDP development and the Czech stock market.

5 Conclusion

After analyzing the sectoral structure of GDP and the stock markets of selected countries (Ireland, Finland, Austria and the Czech Republic) it can be stated that the stock index structures and the GDP structures show considerable differences which is in line with the hypothesis no. 1. It also demonstrates that there is no positive relationship between them, particularly in Austria and the Czech Republic. The stock markets in these countries do not fully fulfill the signaling function for the needs of a new phase of the Industrial Revolution (Industry 4.0). This is shown in the following table which shows the correlation between GDP and stock indices for selected countries.

Table 4: Correlation between quarterly GDP and stock indices changes (1990-2020)

Country	Correlation
Ireland	0.18147277
Finland	0.25492823
Austria	-0.02020210
Czech Republic	0.09312341

Source: own processing in Gretl software

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https://doi.org/10.53465/ER.2644-7185.2022.3.278-296

The situation in Finland contrasts with the above two countries, which is also shown by the highest correlation between the stock market and the economy. As a country with a small economic dimension, it has a significant share of the stock market in the new technologies that underpin future structural changes in the economy. In Finland, the stock market fulfills its function and signals in advance in which direction the economy could go.

The situation in Ireland is rather paradoxical as there is the highest share of new technologies in GDP but at the same time the stock market sends only weak signals to support new technologies. This is probably also related to the government policy, which in Ireland supports new technologies in the private sector as well through various projects including government initiatives. . Nowadays, Ireland is also known as the center of the start-up environment in Europe. The stock market might profit from this in the future in terms of potential IPOs.

A similar link can be observed in the Czech Republic where, compared to Finland, a greater representation of new technologies in the GDP structure can also be observed but, as in the case of Ireland, not yet in the stock index structure.

The onset of the Covid 19 pandemic slowed down the restructuring processes of the mentioned economies in accordance with the requirements of Industry 4.0 and at the same time contributed to a slowdown in the development of stock markets, which contribute to the intensification of financial flows to the economies. The restart of stock markets could contribute to the implementation of large-scale changes even in small economies in the future.

Acknowledgments

This paper is an output of the scientific project VEGA 1/0221/21 “Interest rates in the environment with central bank digital currency” and „ APVV-20-0359 - Covid-19 pandemic, macroeconomic development, food security and household wellbeing”.

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