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Changes in industrial structure of GDP and stock indices also with regard to the Industry 4.0

review paper

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Abstract: The second half of the 20th century brought breakthroughs in the field of science and technology, which significantly affected not only the growth of labour productivity and economic growth, but also brought changes in industrial structures and changes in share of individual industries in GDP. Even more strikingly, these changes have been reflected in the stock market, with leading companies from the field of information technology, which affect the flow and processing of information in revolutionary way. The onset of so-called internet economy at the beginning of the 1990s significantly changes also the structure of stock indices. Business services lure investors particularly into the area of financial services, which also show high degree of appreciation of the investment. New phenomenon nowadays is and expected changes in industrial structures not only in GDP, but also in the structure of stock markets will be brought by new phase of industrial revolution Industry 4.0. The aim of this paper is to quantify and analyse the current state and position of individual industries in the structure of GDP and stock indices and to outline new tendencies and to predict changes in these indicators with regards to the realization of 4th phase of industrial revolution.

JEL Classifications: L70, L88, G19

Keywords: Industrial analysis, indicators of industry, industrial structure of GDP, structure of stock indices
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1. Introduction

Over the previous two decades, the industrial structure of GDP is significantly changing. Even more pronounced changes are reflected in the composition of stock indices, which makes possible to say that composition of stock indices has been cut off from the real economy. This development is marked by another accompanied process as the increase in the frequency of bubbles in the stock.

The issue of industrial classification has been studied by many researchers in the past. The area remains important nowadays as well. In the 1990s the focus of the industrial analysis was mainly on the restructuring processes of the economy in connection with the onset of the so-called internet economy. Roll (1992) and Sampler (1998) highlight the issue of new structures in the connection with the size of the firm within the industry. These changes are associated with significant changes in concentration and diversification within industries. Porter (2008) made an important contribution to the industrial analysis, especially in the connection with strategies and business boundaries. Bernstein (2003) assumes that companies belonging in one industry should have some common characteristics, common development of stock yields. Chan, Lakonishok, & Swaminathan (2007) add that market prices of stocks belonging to the one industry should respond similarly to exogenous factors. The problem of structural changes related to the future

growth of GDP has been highlighted by Laitner (2000) as well. Kadeřábková & Jašová (2011) refer the concept "mezoeconomy", focusing on the economy structure and its changes in the terms of sectors and industries. In their research, they focus on a deeper analysis of industries, their specific structures and the selection of representative groups of companies. The relationship between the stock market and macroeconomic environment are also quantified by Slovak researchers Bikár & Hodula (2016). The center of their attention is German index DAX 30 and British FTSE 100. Using the Bayesian vector regression model (BAVS) they tried to show possible changes of stock indices related to changes of macroeconomic environment. In detail, Baumöhl, Lyócsa, & Výrost (2011) address the issue of industrial analysis in their monograph, where they pay attention not only to industrial classification, but also to performance measurement using the Concentration Index (CI) or Herfinadl-Hirschman Index (HHI). The quantification of industrial changes related to economic growth was realized by Desmet & Parente (2012), in connection to this, they also pointed to the growth of household wealth.

Significant changes in GDP structure and stock indices in 1987 have been highlighted by Sweezy & Magdoff (1987). Foster & Magdoff (2009) introduced into the theory the so-called financialization concept of the economy. Stiglitz (2015) points to that phenomenon and based on the analysis of US economy he talks about the need to fix the financial sector, dropping the "too big too fail" principle and the new technologies as the source of future growth of US economy.

Industry 4.0 is associated with several publications that try not only to explain the nature of the new upcoming phase, but also they look for the context of many economic processes. Gilchrist (2016) connects this phase of revolution especially with the advent of the Internet to all spheres of economy. Yevsikov, Korovin, & Sarygulov (2017) focus also on expected changes and impacts in the industrial structures of economy.

2. Aim and methodology of research

Presented contribution combines the issue of structural changes in economy and their impact on stock market. Our intention is, therefore, to look for the relationship between two basic macroeconomic indicators such as GDP and stock market. We will consider both the previous periods and the expected onset of 4th phase of industrial revolution. In the context of deeper examining and determination of the goal, we set the two basic questions:

1. To which extent does the development of stock index reproduce changes in industrial structures of GDP?
2. Will the 4th phase of industrial revolution bring changes in GDP structure and stock index, outline the possible changes?

From the methodological point of view when quantifying those relations, we have used method of correlation and subsequent regression analysis. Bravais-Pearson correlation coefficient has the following form:

$$r = \frac{\Sigma(R\_GDP_t * R\_S\&P_{t-3}) - n * \emptyset R\_GDP_t * \emptyset R\_S\&P_{t-3}}{(n-1) * SD(R\_GDP_t) * SD(R\_S\&P_{t-3})} \quad (1)$$

Where: r - the value of correlation coefficient; R_GDP_t - YOY change of US GDP in the time t measured on quarterly basis; $R\_S\&P_{t-3}$ - YOY change of S&P 500 Index in the time $t-3$ measured on quarterly basis; $\Sigma(R\_GDP_t * R\_S\&P_{t-3})$ - sum of the product of two characteristics R_GDP_t and $R\_S\&P_{t-3}$; n - number of observations; $\emptyset R\_GDP_t$ and $\emptyset R\_S\&P_{t-3}$ - average values for R_GDP_t and $R\_S\&P_{t-3}$ respectively; $SD(R\_GDP_t)$ and $SD(R\_S\&P_{t-3})$ – respective standard deviations.

Regression analysis has the following form:

$$R\_GDP_t = \alpha + \beta * R\_S\&P_{t-3} + u \quad (2)$$

Where: α; β - coefficients; u - white noise.

When processing this issue, we obtained data from official statistics and institutions, such as Bureau of Economic Analysis, US Department of Commerce, US Department of the Treasury. When monitoring the development of stock market, we have processed the official data of stock index S&P 500. Similarly, we have also monitored changes in economic structures of Germany and Japan, where we have used official data from the European Central Bank (ECB) and the Central Bank of Japan (BOJ). We also used the Bloomberg database.

3. Changes in industrial structures and their analysis

The problem area for the investor today is the differences in classification methodologies; various researches prove that the use and comparison of individual classifications often show incomprehensible results.

The fundamental problems of existing industrial classification are: existence of various data providers with different classification; changes in business activities; various degree of diversification of companies within the industry.

The composition of industrial structures is changing significantly today, while the traditional structure of the industry with the companies concerned has been maintained for the relatively long time in the past. During the 20th century, there has been a significant change and shift, in particular, in the industrial order of development and access to GDP. Over the last two decades, there have been a significant changes in industrial structures, as a whole new industry is emerging - technologies with new companies. The newly emerging industry of the economy intervenes and also changes the character of traditional industries and their companies (e.g. energy, transport, services etc.)

Under the current conditions there is often very difficult to include a company in the industry, also because companies are often so diversified that that they can hardly be classified into the one industry. Specifically, this issue applies to holding companies - large corporations that are doing diverse businesses.

The analyst´s role in industrial analysis is to identify the characteristics of individual industries and also to forecast the development of these industries. As basic elements in the characteristics of industries he also selects: the sensitivity of industries to the individual

phases of economic cycle; the way of government regulation; and the type of industrial structure.

When examining industry sensitivity to economic cycle, one can integrate the different industries into these categories:

- *Cyclical industries* are the ones that are copying the economic cycle, which means that their production is growing during the expansion period and conversely, it is declining during the recession mainly due to low sales, low consumer demand. Such decline also has negative impact on the stock exchange development as well. They are e.g. the automobile industries, consumer durables, building industry.
- *Neutral industries* that are not influenced by economic cycle, because their price elasticity is fairly low (e.g. alcohol, cigarettes, newspapers).
- *Anti-cyclical industries* are those that show good results in the time of recession (e.g. cable TV serves as an alternative source of entertainment at higher price session of other types of entertainment).

Given that in many economies there is still considerable influence from the state and its interventions, many industries do not avoid the influence of state regulation. In many cases, the state, for example, sets maximal prices for various services such as electricity, gas, communications, what indirectly affects the profits of these companies and, therefore, their stock prices. On the other hand, the prices of these companies´ shares in the markets show lower volatility, which is also less risky for the investor. The state can also through direct interventions (such as licensing) limit the entry of other entities into the industry, thereby affecting the level of profit in companies already operating.

The development of stock prices is also conditioned by the organizational type and the structure within the industry. If some producer has a monopoly position within the industry, it is logical that such a producer will achieve a steady amount of profit; therefore, stock exchange rate will be fairly stable and a safe investment for the investor. If the industry has an oligopoly structure, with the industry controlled by a small number of producers sharing the market with each other and having a common pricing strategy, we can deduce that the industry has also a fairly stable earnings income and, therefore, stock prices do not show high volatility.

There is a high volatility in profit and equity rates in the sector where many competing manufacturers operate. Of course, in such industry a fundamental analysis is very difficult and it is not easy to predict its development.

The analyst at the industrial analysis level relies on the short and long-term horizons. In the short term, the analyst monitors: which industries achieve the higher increases in profit; which industries exhibit the best improvement in the indicator P/E; the movement of interest rates and which sectors are most sensitive to this move; in which industries political events have a significant impact.

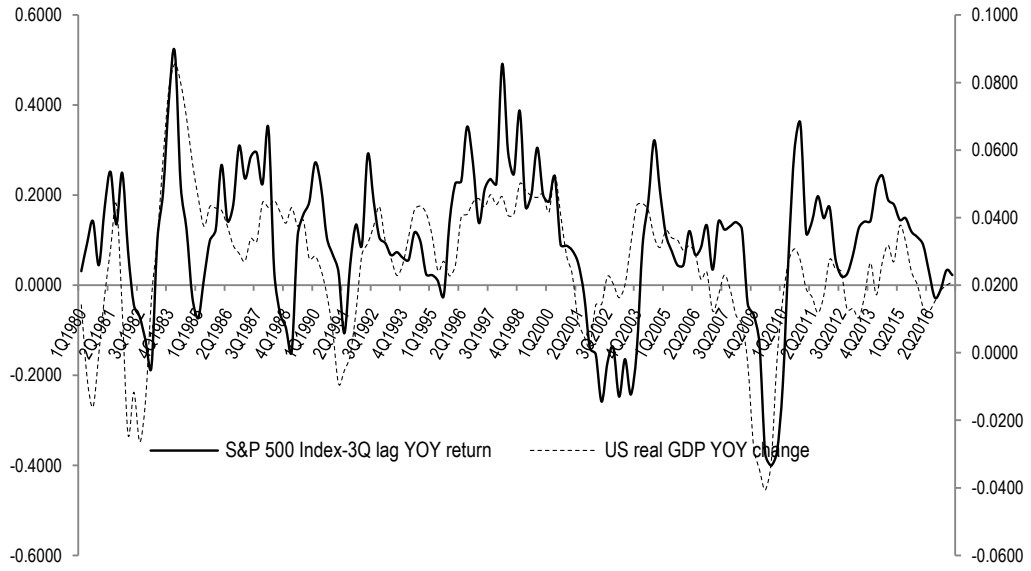
For long-term forecasts, the analyst must also take into account global trends and expected structural changes in the economy. From this point of view, he then monitors: industries which will exhibit growth in the long run; industries which, on the other hand, will be on the decline or fail in the restructuring of the economy and the transition to an information-type economy.

3.1. Correlation between stock market and GDP in USA

The relationship between GDP and stock market in the United States in the long-term horizon shows some anomalies that we will try to justify. The Figure 1 monitors the development of GDP and stock index S&P 500 and based on the correlation coefficients we will try to explain and prove to which extent the stock market replicates the development of economy measured by GDP. The figure clearly shows that stock market and real economy are developing in the same direction. However, there may be considerable discrepancies in the development of the stock market and real economy. Declines in the stock market exhibit more significant deviations downturns than the real economy, for example in 1989, 2002. Similarly, we can monitor higher growth of stock market compared to economy in 1998-99, or in 2010-11.

When quantifying this relationship with correlation coefficient, we concluded that that strong correlation between stock market and GDP was reflected particularly during 1990-1999, and very strong correlation between the development of stock index and GDP is evident from 2009 to present (Table 1). Stronger correlation between the development of GDP and stock market also results from bursting of stock bubble in 2008 and the restarting of stock markets in 2009, while in these times the stock markets reflect economic development more realistic. This fact can also be observed in the Figure 2.

FIGURE 1. YOY CHANGE OF S&P 500 INDEX-3Q LAG AND US REAL GDP



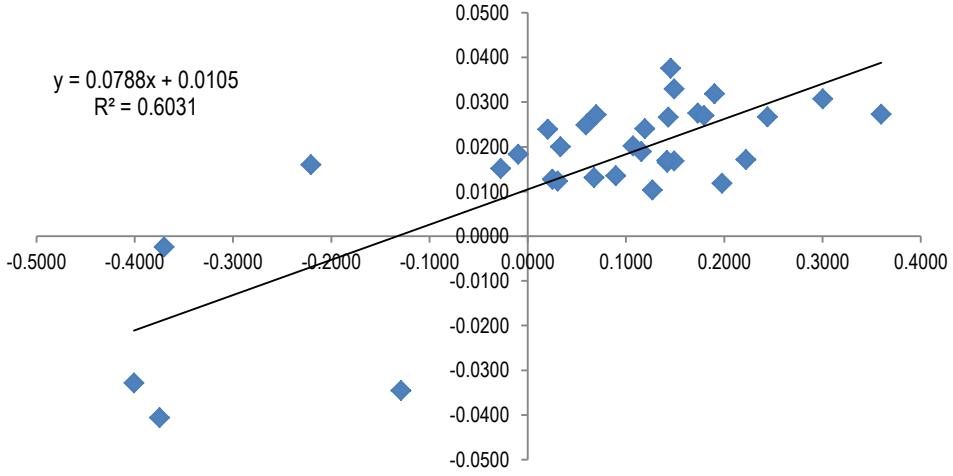
Source: Own processing, data extracted from http://us.spindices.com; https://www.bea.gov.

TABLE 1. CORRELATION BETWEEN US GDP AND S&P 500 INDEX
3Q (YOY change) in selected time ranges

TIME RANGE	CORRELATION COEFFICIENT	T-STATISTIC	CRITICAL VALUE	RELATIONSHIP
1980 -1989	0.4269	2.948	1.685	moderate
1990 - 1999	0.5900	4.563	1.685	strong
2000 - 2008	0.3754	2.396	1.690	moderate
2009 - present	0.7730	7.000	1.692	very strong

Source: Own processing.

FIGURE 2. CORRELATION BETWEEN US REAL GDP AND S&P 500 INDEX
3Q lag (YOY change) (2009 - present)



Source: Own processing.

For the same time ranges we made also regression analysis (Table 2), where we have studied the relationship between S&P 500 Index as an independent variable and US GDP as a dependent variable. Similarly, we used monthly data that represent YOY changes, where data for S&P 500 are shifted three months back. It means that the value of index change for the fourth quarter of a given year in the model is actually the value corresponding to the first quarter of the same year. In addition, the values for both indicators are log-transformed. Except of the time range 1990-1999 the coefficients for the independent variable have shown to be statistically insignificant at the level of significance $\alpha = 0.05$. Although in the period before bursting of dot.com bubble the coefficient for S&P 500 is significant, such a model is able to explain only 14.4% of the variability of GDP changes. Thus, based on these results we can conclude that changes in the S&P 500 Index do not directly influence changes in US real GDP.

TABLE 2. RESULTS OF REGRESSIONS US GDP AND S&P 500 INDEX IN SELECTED TIME RANGES

RESULTS OF REGRESSIONS	(1980-1989)	(1990-1999)	(2000-2008)	(2009-PRESENT)
constant	-1,13306	-0,56123	-1,14209	-1,46940
standard error	0,50782	0,62277	0,55241	1,26101
t Stat	-2,23123	-0,90118	-2,06746	-1,16526
P-value	0,03164	0,37317	0,04637	0,25253
coefficient for S&P 500 YOY Change	0,26211	0,42973	0,27425	0,19272
standard error	0,13968	0,16974	0,13993	0,31925
t Stat	1,87649	2,53175	1,96000	0,60365
P-value	0,06828	0,01561	0,05823	0,55033
F	3,52121	6,40975	3,84162	0,36439
Significance F	0,06828	0,01561	0,05823	0,55033

Source: Own processing.

3.2. Changes in industrial structures of US GDP and stock market

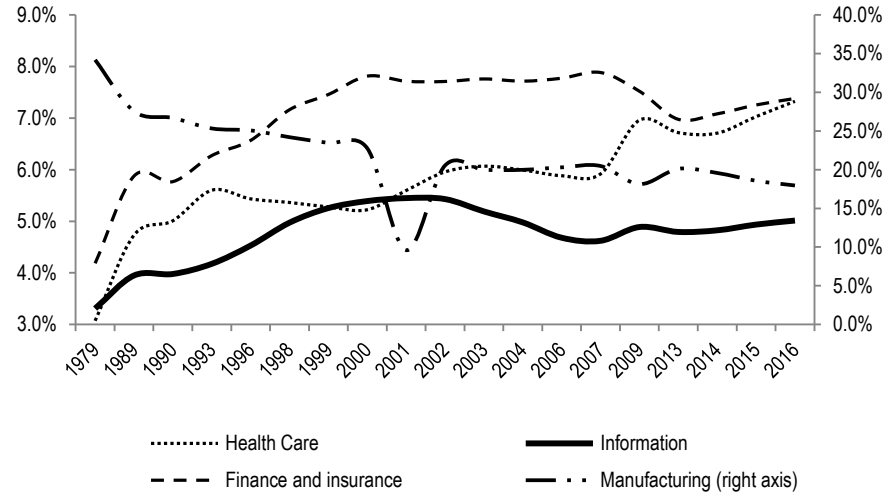
In 1979, manufacturing had the largest share to US GDP, accounting for up to 20.41% of GDP. The second most represented sector is retail with 11.1%. Professional and business services were the third most important sector of GDP generation in 1979: the sector generated 6.65% of GDP. The smallest share of GDP was recorded in 1979 in three sectors. The first was real estate sales, rental and leasing, which contributed 1.3% to total GDP. This sector was followed by the mining industry, which accounted for 0.93% of domestic product this year. The smallest share on GDP, however, had public works, which accounted for only 0.66%. In the 2015 there can be observed more significant changes in the industrial composition of GDP. Share of the manufacturing to GDP declined sharply (from 20.41% to 12.0%). Share of financial services and information technologies to GDP has grown almost twice.

Gradual changes in contribution of industries to US GDP can be seen in the Figure 3. For simplification we chose the industries that most contribute to the growth of GDP or stock market, but at the same time reflect the most significant changes.

More marked changes are visible in the structure of index S&P 500 (Figure 4). Information technology and financial services today with their market capitalization account for more than a third of the index. Energetics, that had significant presence in the S&P 500 stock index in the past, decreased significantly in its weight within the stock market..

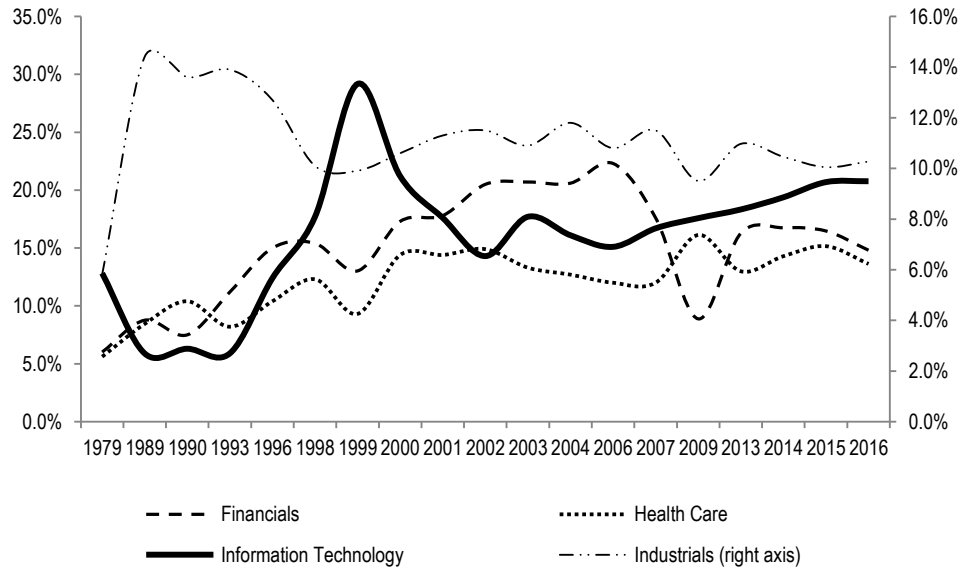
In the terms of structure of stock index, we can conclude that most noticeable growth was recorded by IT industry and financial services. The development of these two industries is also linked to two bubbles on stock markets - the technology bubble in 2000 and financial bubble in 2008. Low growth was exhibited by health care and manufacturing had a steadily declining share in the stock market

FIGURE 3. REPRESENTATION OF SELECTED INDUSTRIES IN THE STRUCTURE OF US GDP (SELECTED YEARS)



Source: own processing, data extracted from https://www.bea.gov.

FIGURE 4. REPRESENTATION OF SELECTED INDUSTRIES IN THE STRUCTURE OF S&P 500 INDEX (SELECTED YEARS)



Source: Our processing, data extracted from http://us.spindices.com; http://siblisresearch.com.

3.3. Industrial structures of GDP and stock market in Japan and Germany

Japanese GDP is composed of three main components, namely private sector, public sector and non-profit sector. The bulk of Japanese GDP is services. Their share represents up to 19.76% of the total output of the economy. The second most represented industry in the Japanese economy is manufacturing production, which account 18.67% of the total output of the economy. Wholesale and retail have the third largest share on domestic product, which accounts for 14.20% of GDP. Such a structure is almost identical compared to the first half of the 1990s. Obviously, this is also related to the problems of the Japanese economy, which fell into recession and stagnation after the bubble burst in 1989.

The current situation on the Japanese stock market is assessed by many investors based on the Nikkei 225 stock index which includes 225 Japanese companies. The structure of the Nikkei 225 stock index is divided into eleven sectors, with 22.82% of consumer spending (retail) being the largest. Manufacturing enterprises had second biggest share in the stock market, which make up 22.72%. The third largest share of the index is held by IT companies, whose weight is 14.29%.

Sectorial composition of German GDP significantly differs from the composition of DAX stock index. The largest differences can be observed in three sectors, namely in financial sector, the manufacturing sector and public services (respectively in sector of public services). Financial services are the second most represented sector in the DAX index with a total share of up to 19.44%. However, the same sector accounts for only 3.92% of the output of the German economy in the same year. The share of financial services in GDP and the stock market is diametrically different. The share of financial institutions in the stock market is almost 5 times higher. The second very different sector is manufacturing production. While the manufacturing generates more than a quarter of GDP (25.77% of GDP in 2015), it is less than half in the stock market. It has a share of only 11.38% on the DAX stock index. We also see very large differences in sectorial composition in the case of public services. While these services form the second most represented sector on GDP with a share of 18.26%, the lowest share of the services is in the stock market (2.55%).

When comparing with US economy and stock index, Japan and Germany have significantly stronger representation of manufacturing in the composition both of GDP and stock market.

4. Emerging of so-called financialization of the economy

Financial sector and its services are currently the most dynamically evolving area of almost every economy. Their share of GDP growth has been steadily rising; there is the largest amount of fictitious assets, different transactions and innumerable quantities of overvalued products in this sector. The financial sector contributes to a great extent to the virtualization of the economy and the financial system (Table 3).

Foster & Magdoff (2009) in the study of the Great Financial Crisis and consequences show that economy´s focus is shifting from productive industries to financial services, They have suggested a new concept of so-called "financialization of the economy". The growth

of financial sector is associated not only with the relative but also absolute growth of employment, which has also resulted in transfers within the industrial structures. The financial sector binds the most highly qualified segment of the labour market in a large volume. The financial sector demands on the quality of workers are connected with highly sophisticated financial products and, the entire global financial market has gone through a high degree of intellectualisation.

TABLE 3. THE SHARE OF FINANCIAL SERVICES IN US GDP (%)

	1970	1980	1990	2000	2010	2015
Financial sector share	4.128	4.906	5.861	7.543	7.21	7.41

Source: Processed from www.bloomberg.com.

TABLE 4. THE SHARE OF FINANCIAL SERVICES IN S&P 500 INDEX

YEAR	1979	1990	1995	2000	2005	2010	2015
% SHARE	6.01	9.8	12.08	17.2	21.04	15.1	16.47

Source: Processed from www.marketcapitalisation.com.

The growth of the share of financial sector to GDP is often associated with significant speculation, which is difficult to quantify at the present time. Measuring the real book value of financial sector shows a big problem due to the speculative nature of financial instruments. It is logical that financial transactions require deregulation, which ultimately leads to the growth of destabilizing tendencies and the formation of increasingly larger financial bubbles. Sweezy & Madoff (2009) argue that the financial expansion is linked to the stagnation of the other spheres of the economy. Over 90s, two trends can be traced to the stock market: huge growth in the share of equity indices of firms associated with internet economy; and significant growth in the share of financial services in equity indices.

American companies of so-called new economy are in great attention to investors in the stock markets. The internet economy grew by 11% in 1999, while the entire economy exhibited the growth rate of 4.2%. Thus, internet economy´s sales also outstripped industries such as the automobile and insurance industries. The strong influence of financial institutions on the economy conditioned the increase in the share of stock indices.

While financial services made share to US GDP of only 7.89% in 2010, the share of financial sector made 15.1% in the S&P 500 structure (Table 4). These data lead us to the conclusion that the stock market does not always replicate the real economy and is currently largely marked by the speculative component of the financial sector.

In Japan and Germany, the financial sector does not record such a significant increase of share in GDP. In the case of Germany, the financial sector recorded a decline compared to 2015 compared with 1990. In Japan, the financial sector did not record significant

growth in the stock index. The German stock market is already showing the tendency of strong growth in the financial sector´s share of the DAX stock index.

5. The onset of Industry 4.0 and changes in industrial structures

In recent years, the economic analysts highlight the slowdown in labour productivity and the week economic growth. The revival of growth in labour productivity and economic growth is now related to the need to implement of 4th Industrial Revolution. The aim of this phase is to bring back manufacturing production to Europe at a higher technological level, which will compete with the productivity so-called cheap countries. This idea is associated with the use of internet and digitalization, artificial intelligence, robotics, the internet of things, 3-D printing, biotechnology, energy storage and quantum computing. The cyber-physical system that is applied within companies, will contribute, according to experts, to a 30-40% increase in labour productivity. Considerable interest in this issue has been raised by by Brynjolfsson & McFee (2014).

What kind of changes in industrial structures can be expected in relation with realization of 4th phase of Industrial Revolution? The current leadership of IT companies in industrial structures from both the GDP and stock market will be even more robust. This is also related to the growing diversification of activities within the industry itself, because IT companies are beginning to enter the various industries of economy. The most obvious example is the entrance to the area of financial services - banking. In the past, technological companies have been involved in financial services as co-operating partners of banks, whose task was to provide higher quality of services for banks and their clients. The directive EU- PSD2 (Payment services Directive) has created favourable conditions to fintech companies. The regulation allowed competing banks to enter the execution of payment transactions. This trend can also lead to a decline in profitability of banking sector, which has, to date, provided almost full payment with relatively high fees. This phenomenon may also be reflected in a change of industrial structure of, in particular, stock indices, where financial services in relation directly to bank joint-stock companies may no longer have such a significant position in the future.

With the onset of Industry 4.0, the robotization of manufacturing will place increased demands on mechanical engineering. The need for new types of materials, construction elements, and robot construction will require the co-operation of sophisticated IT technologies as well as engineers. It is also possible to expect the growth of engineering that will work with the latest technologies.

As in the 1990s, when new services emerged with the onset of technological revolution, the emergence of new high-tech wave may also result in the emergence of new services which will be coupled with a significant shift of labour.

6. Conclusion

Mainly the last two decades exhibit significant changes in industrial structures. Not only is their share in GDP creation changing. So-called new economy is emerging and it is definitely associated with new technologies - especially with the internet in 1990s. Traditional industries, in particular manufacturing, are declining in their share in GDP and the informatics comes to the forefront. These changes are even more pronounced in the

structure of stock indices, where the dominant position is acquired, besides informatics the industry of financial services. The data show that industrial structure of indices no longer correspond to the GDP structure, which suggest that stock market does not copy the economy. In connection with significant growth of financial services, a new phenomenon has emerged - financialization of the economy and, in particular, of markets. With the onset of Industry 4.0 significant changes in industrial structures of GDP and stock markets are likely to be expected. At the high level of robotization, it is possible to assume that again, in addition to the latest technologies, the role of manufacturing, which will provide the entire process of robotization with IT, will be enhanced. We assume that the financial service sector, which is particularly demanding for human capital, will in the near future show a decreasing trend.

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