



University of Hradec Králové  
Faculty of Informatics and Management

# Hradec Economic Days



Vol. 14  
proceedings of the international scientific conference  
Hradec Economic Days 2024

April 11–12, 2024  
Hradec Králové, Czech Republic



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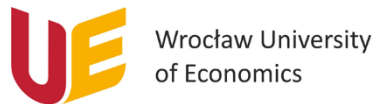
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## Preface

Ladies and gentlemen, dear colleagues,

the Hradec Economic Days (HED) conference has been traditionally and continuously held since 2003. This year we are opening a new decade with our 22<sup>nd</sup> HED which took place April 11–12 in Hradec Králové. The University of Hradec Králové organized the conference in cooperation with the Wrocław University of Economics, the Cracow University of Economics.

The aim of the HED 2024 conference was to present the results of scientific research activities in the fields of economics, business economics, and management. We became a regular platform for meeting experts from such disciplines strengthening interdisciplinary relations and establishing personal contacts important for the submission of joint research projects and creating space for the presentation and publication of young members of an academic community. To fulfill these goals, we provided presentation sessions and a plenary session with foremostly keynote speakers:

- Alan Gibbons (Ambassador of Ireland to the Czech Republic),
- Magnus Svendsen & Jørgen Sjøvik (Founders of Oslo Analytic),
- Josef Diblík (External CFO and Consultant).

To boost academia and practice interconnection, we also prepared discussion sessions:

- Entrepreneurial Mindset & Team Building,
- Shareholder value and value creation.

Proceedings from the conference HED 2024 contain 45 contributions in English. The authors of the conference papers were academics and other professionals from the Czech Republic, Poland, China, Slovakia and Spain. I would like to warmly thank all participants of the HED conference for their contributions and favor. The final recognition belongs to the HED secretary assoc. prof. Ivan Soukal, editor Dr. Jan Mačí, our organization, and scientific committee for their work. I would like to thank our co-funding our partners: the project no. EHP-BFNU-OVNKM-4-214-01-2022 of the EEA Funds 2014-2021 and the grant no. 24RGI02-0077 of the Hradec Králové region.

Hradec Kralove, April 10, 2024



Assoc. Prof. Petra Marešová  
General Chairman of Hradec Economic Days  
Faculty of Informatics and Management  
University of Hradec Kralove

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# Is Agriculture 4.0 in Czech Republic More Real than Industry 4.0? Analysis of Selected Macroeconomic Indicators

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**Abstract:** In recent years, there has been a lot of talk about the introduction of new technologies into the production process due to Industry 4.0 initiative, and in agriculture, Agriculture 4.0. Based on the analysis of data from Eurostat, it appears that the importance of the agricultural sector in the Czech economy has been decreasing since the 1990s, its performance and productivity are not adequate compared to other sectors. However, according to the available data, the agricultural sector can be characterized as an area of the economy in which the Agriculture 4.0 initiative has been manifested itself in recent years, especially in terms of evaluating the year-on-year growth of the relevant components of fixed assets. Even if the manifestations of this initiative are not reflected in the overall state of the sector assessed through labor productivity or the hours worked per person, the dynamics of the use of new technologies has been more pronounced in agriculture in recent years than in the rest of the Czech economy. It can therefore be concluded that the Agriculture 4.0 initiative in the Czech Republic has its impacts with positive prospects for the future.

**Keywords:** Industry 4.0; Agriculture 4.0; macroeconomic analysis; labor productivity; total assets analysis

**JEL Classification:** Q16; E24; O13

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## 1. Introduction

Human activity is constantly accompanied by the effort to achieve better results. At the same time, we seem to be naturally wired to want more, to satisfy our needs to a greater extent, and our needs are inherently unlimited. Since we have only limited resources available to satisfy our needs, both in terms of obtaining them from the position of consumers, and in terms of their production from the position of producers, we are forced to manage the production process. It can be manifested in many ways, one of which is deciding what kind of consumption we choose to consume, as consumers, or what goods we choose to produce, as producers. Either way, it's essentially a question of resource efficiency and a question of productivity. These motives force us, as human beings in the role of consumers and producers, to think economically about the connections between our consumption and production. Thus, we are trying to increase the efficiency and productivity of our efforts to obtain more resources to meet our needs.

When such considerations lead to innovations in the production process, which can subsequently be identified as a turning point, then we can talk about revolutionary changes.

If such changes concern the industrial way of production, then we can label them as industrial revolutions, and if they concern significant changes in the approach to production in agriculture, then as agricultural revolutions. In history, humanity has already gone through several such changes, which have had an impact on the way we approach production and consumption itself.

The first such radical change in the way of industrial production, today referred to as Industry 1.0, was the introduction of the steam engine and its use in production. After the expansion of this approach to industrial production, there was a radical change in labor productivity, which led to an increase in the volume of production. Of course, such a change required sufficient capital investment made by producers, and at the initial moment led to the replacement of human labor by mechanization. However, its positive effects subsequently enabled an increase in production and consumption, and led to an increase in employment.

The second identified turning point was the introduction of scientific management and the industrial method of production. It stimulated the emergence of mass production, factory lines and further increased labor productivity and the efficiency of the production process. Together with this approach, the approach of unification and standardization was introduced into production. This change was labeled as Industry 2.0.

The use of other innovations in the production process is associated with the third wave of industrial revolutions, which is characterized using electricity, computer technology and automatization of the production process. We call it Industry 3.0 (Gashenko et al., 2020; Lazanyi & Lambovska, 2020).

What those industrial revolutions have in common is that they have been retrospectively identified as turning points in the production process, with long-term effects on society and production process. The following waves of industrial revolutions are connected by the fact that they are already consciously induced by man, with the aim of intensifying and deepening radical changes in the production process, leading to an increase in productivity and production efficiency. The impact is then supposed to be an increase in the quantity of goods produced and a reduction in the price of the given production, making the given production more affordable for consumption and at the same time more competitive on the market.

In this sense, we are talking about the Industry 4.0 initiative, which is based on a cyber-physical combination of production means, the use of advanced communication technologies, the Internet, augmented and virtual reality, artificial intelligence, remote control and interconnection of information systems, and other modern technologies. However, the significant emphasis on the technological side, which is contained in the Industry 4.0 initiative, can be perceived as a significant threat to the human position as part of the production process. This is also the biggest criticism of the Industry 4.0 initiative, namely that man as an employee will become unnecessary and will be replaced by machines in the production process. Even if these concerns turn out to be odd, the reactions have manifested themselves in the form of the Industry 5.0 initiative, which emphasizes the position and cooperation of humans in the future organization of production processes (Beke et al., 2020; Brahma et al., 2021; Flores et al., 2019; Grenčíková et al., 2021).

In the field of agricultural production, of course, the mentioned tendencies are also manifested, especially if we look at agricultural production as a part of industrial production. However, here we can also trace specific moments beyond the above-described influences aimed at increasing the productivity and efficiency of agricultural production. Among these influences we could include the discovery of new crops that is associated with the discovery of the world, approaches to increase yields from cultivated agricultural land, such as two-field and three-field systems, or the use of fertilizers and pesticides in agricultural production.

Currently, agricultural production is similar to the Industry 4.0 initiative, which is referred to as Agriculture 4.0. This initiative is associated with intensive use of new technologies in agricultural production. Even in the Czech Republic we can encounter the use of livestock sensors, automatic milking technology, automatic feeding technology, automatic faces handling systems, air conditioning units for pig and poultry farming, autonomous tractors and harvesting equipment, use of drones and satellite data, or soil sensors and capacitive sensors and many other new technologies use in agriculture production process (Marinič, 2023).

The previous analyses (Marinič & Pecina, 2021; Marinič, 2022) indicated that in the Czech Republic Industry 4.0 is rather a gradual process of evolutionary change of the production process than a radical change in the approach to industrial production. Thus, that the Industry 4.0 is rather evolutionary change than rapid revolution in production process. It is based on analysis of chosen economic indicators of the whole Czech economy. Of course, even in the Czech economy there are innovative producers who use available new technologies, however, their share in the total number of economic entities will obviously not be significant, since the impact of the introduction of the Industry 4.0 initiative is not reflected in significant changes in the overall data. On the other hand, if we wanted to identify a sector in which more significant changes may occur as a result of the implementation of the Industry 4.0 initiative, it would be the agricultural sector (Marinič, 2022).

In the context of the expected impacts of the Industry 4.0 initiative, there should be a sharp increase in labor productivity, measured as a share of output per employee, in companies that will use new technologies, as these producers will use non-negligible technological equipment that will contribute to increasing the volume of production, while reducing number of employees, or at least while maintaining their level. At the same time, this should be reflected in the volume of growth of fixed assets, and thus also in the increase in cost of fixed capital.

The goal of the paper is to analyze selected macroeconomic data that could be an indicator of the impact of the Industry 4.0 initiative in the Czech economy. Since the contribution is focused on the agricultural sector, attention is paid to comparing this sector with industry and the service sector, as well as with the data for the entire Czech economy.

## 2. Methodology

The aim of the contribution is to identify the impacts of the Industry 4.0 initiative with a focus on the agricultural sector, i.e. to identify the impacts of the Agriculture 4.0 initiative, because previous analysis (Marinič, 2022) indicated a potential impact in this sector.

The analysis is based on publicly available data through the Eurostat database, specifically using data sets under the code designation:

- nama\_10\_nfa\_st (gross fixed capital formation);
- nama\_10\_a64 (the amount of production and selected economic indicators);
- nama\_10\_a64\_e (the number of employed persons and hours worked).

The individual indicators were based on values using the national currency, i.e. the Czech crown, so that it was not necessary to consider the effect of changes in the exchange rate between the Czech crown and the euro. For the calculations of each year ratios, data in current prices were used, however, in the case of evaluating year-on-year changes, available valuation data in the prices of the previous year were used. This eliminates the effect of price changes, i.e. the effect of inflation for individual sectors. For the analysis, the longest available period was used, i.e. data from 1995 to 2022 were used. Due to the length of the assessed period, the potential impacts of the Industry 4.0 initiative, or Agriculture 4.0, should manifest itself in the data of recent years rather than within the entire period under review.

### 3. Results

Due to the length of the period under review, the data from Eurostat, assessing the overall development of the economy of the Czech Republic, can identify the expected development corresponding to changes in the structure of the Czech economy. Development of the selected indicators (Output, Gross Value-Added, Persons, Hours Worked for the whole Czech economy) are in the Figure 1. There are also presented shares of sectors of economy on the total value of the selected indicator for the whole Czech economy in per cent. The changes in structure of the Czech economy relate to the gradual reduction of the share of agriculture at the Output, similarly to the decrease in the share of industry and, conversely, the increasing share of services. It corresponds to the ongoing trends in changes in the economy, which is moving towards a significant strengthening of services in consumption. However, due to the historically traditional significant representation of industrial production in the Czech Republic, the representation of industry and services fluctuates around the value of 50% in relation to the Output in all NACE activities. The share of agriculture decreases from the original 4.2% to 2.4%.

However, a better understanding of the connection of individual sectors to the overall performance of the economy offers a view of the Gross Value-Added indicator, which better reflects the overall GDP of a given economy. Here we can already see the dominant position of the service sector with a growing share (from 56.6% to 65.3%) and corresponding decreases in the shares of industry (from 39.0% to 32.7%) and agriculture (4.4% to 2.1%). A similar change in the structure of the Czech economy is also reflected in the indicators of the number of employed persons and hours worked.

The information not presented in figures but worth mentioning is that the number of hours worked per employee for agriculture is the highest for all time. The indicator, assessed as a ratio of the number of hours worked per employee in relation to the total number of hours worked per employee in the entire Czech economy, is also growing during the analyzed

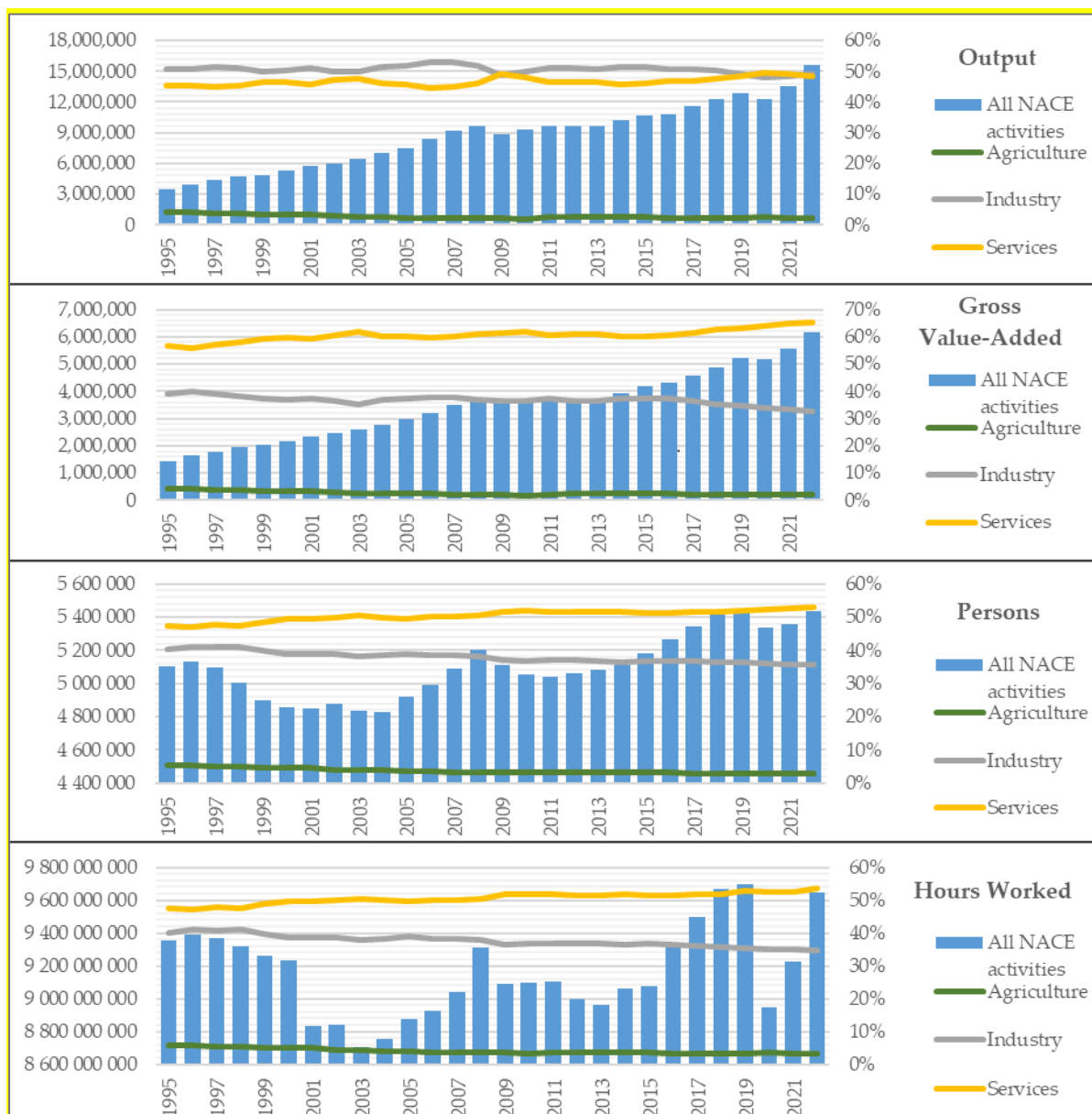


Figure 1. Development of selected indicators (column: absolute values at right axis in millions CZK for output & gross value-added and for persons & hours worked in thousands of units; curves: per cent share of sectors on All NACE activities values at left axis)

period. Therefore, if we were to assume that the implementation of the Agriculture 4.0 initiative will lead to a reduction in the work performance of employees in the given sector, the data does not confirm this assumption. This assumption is fulfilled predominantly in the industry sector, where the number of hours worked per employee is decreasing.

Also interesting, although not presented in figures, is the volume of employed persons, given the recalculated number of employees, which indicates that in the Czech economy, in all sectors, since 2005, there has been a tendency towards short-time employment. The available data regarding the division into persons employed and self-employed persons show that the share of sole-entrepreneurs in the Czech Republic is around 15% in the long term, however, in the agricultural sector this share is constantly increasing from 18.64% in 1995 and will reach 35.48% in 2022.

The labor productivity is another area that should be affected by Industry 4.0, i.e. Agriculture 4.0, initiative. It should increase with the introduction of new technologies to the production process. Labor productivity for individual sectors and for the entire Czech economy can be assessed from through Output per Person ratios, or through contributions to the creation of GDP, i.e. through the Gross Value-Added per Person ratio, both in current prices. In addition to the labor productivity per employee, it is also possible to assess labor productivity per hour worked, which may vary due to the different number of hours worked by employee in individual sectors. Figure 2 provide an analysis of these data.

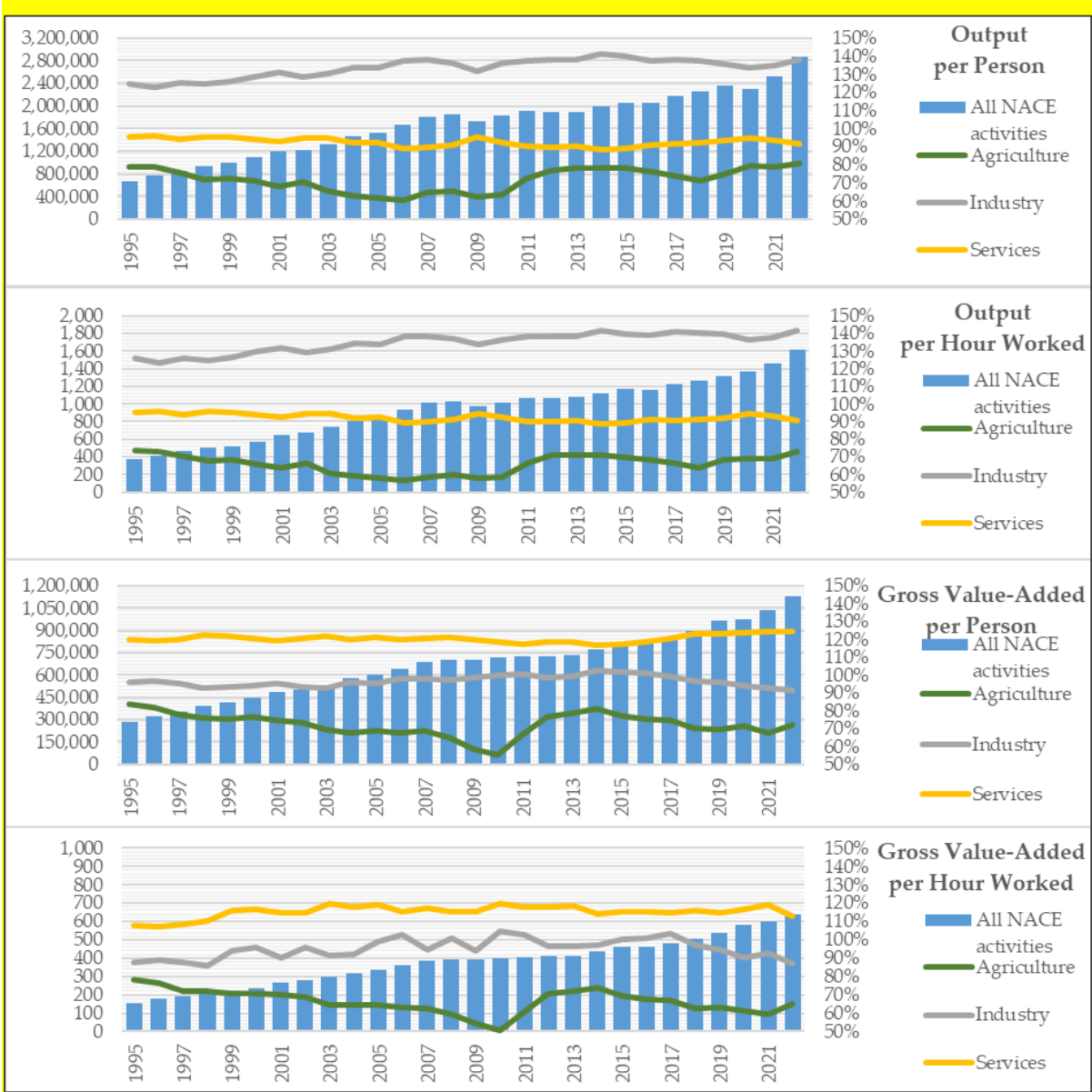


Figure 2. Development of selected indicators (column: absolute values at right axis in units of CZK for output & gross value-added per person and per hour worked; curves: per cent share of sectors on All NACE activities values at left axis)

Labor productivity calculated from Output and Gross Value-Added (Figure 2) in current prices is expected to increase throughout the monitored period, both per person and per hour, due to inflation and implementation of new technologies. It can also be seen that the industry

sector achieves higher values calculated from the Output, while the service sector achieves higher values when calculated from the Gross Value-Added. In both cases, the agricultural sector achieves below-average values compared to the entire Czech economy. According to the Figure 2, it can be seen, that in agriculture there is decreasing trend in productivity till 2010 with the significant increase in productivity in the years after 2010.

However, this analysis is distorted by the effect of year-on-year price changes, and therefore it is more appropriate to look at the year-on-year increase in productivity using values of chosen indicators in previous year prices, which takes price changes into account and reflects values of the real increase in the Output and Gross Value-Added. Such year-to-year changes of productivity according to selected indicators is presented in Figure 3.

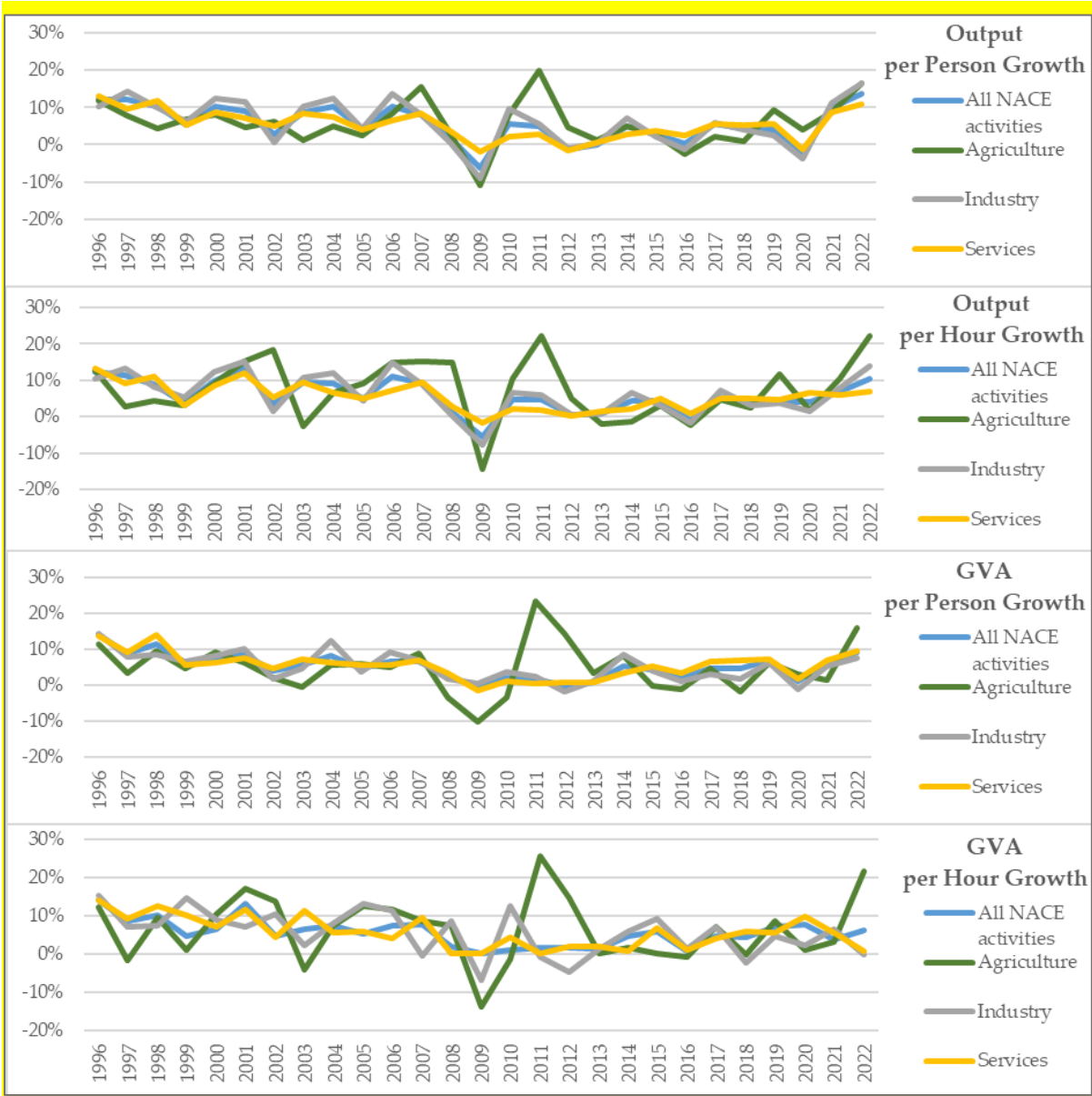


Figure 3. Development of year-to-year productivity per cent change based on previous year prices

As can be seen in Figure 3, changes in the real values of labor productivity fluctuate significantly from year to year. These oscillations are particularly pronounced for the agricultural sector and, moreover, for the Gross Value-Added. The growth of productivity

can be seen in current prices (Figure 2) and previous year prices (Figure 3) in all sectors, with the specifics in agriculture, where there was lag in the labor productivity progress till 2010 with a subsequent revival of labor productivity growth after 2010.

Another area in which the effects of the implementation of the Industry 4.0 initiative, i.e. Agriculture 4.0, should be manifested is the area of costs. Figure 4 provides an analysis of the development of Compensation on Employees and Consumption of Fixed Capital.

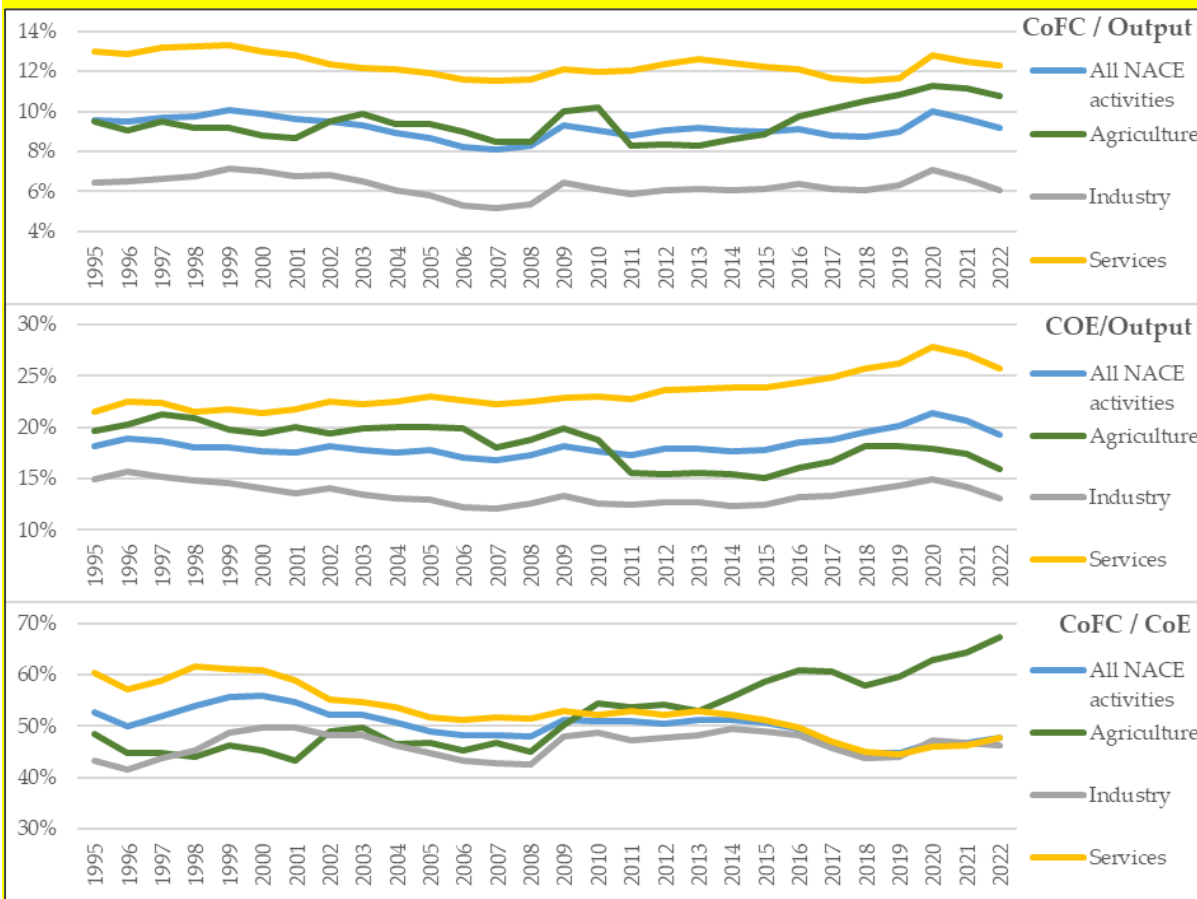


Figure 4. Development of ratios of compensation on employees and consumption of fixed capital to output and their mutual ratio.

Compensation on Employees should increase in total value because of increasing wages of employees, which may increase due to higher labor productivity. Consumption of Fixed Capital should also grow, as there should be a renewal of investments and especially investments in new technologies. Even though both indicators should increase in absolute terms, the effect on the change in their share in the volume of total production may not be so clear-cut, precisely because of the effect of the change in labor productivity and the efficiency of the use of technology in the production process. However, if there were to be replacement of human labor with technological equipment, it should be reflected in the mutual ratio of both indicators.

As can be seen in Figure 4, the mentioned trend of the increase in the costs indicators are manifested in absolute values for the entire analyzed period in all sectors. In the industry and services, this increase in absolute values is also continuous even when looking at year-on-year changes. In the case of industry, it reaches values of 3.84 in the case of Compensation on

Employees and 4.11 in the case of Consumption of Fixed Capital, which indicates a slight increase in the investment intensity of industry. In the case of services, the increase in the value of Compensation on Employees reaches 5.73 and in the case of Consumption of Fixed Capital 4.54, which in turn indicates an increase in the intensity of workforce. In the case of the agricultural sector, there is also an increase over the entire monitored period, namely in the case of Compensation on Employees in the range of 2.06 and Consumption of Fixed Capital in the range of 2.86, which indicates a growth in investment intensity, but the year-on-year development of the absolute value of the indicators is uneven. A more significant increase in values can be identified from 2013, in the case of Compensation on Employees from 2016 respectively.

Compensation on Employees is higher than Consumption of Fixed Capital in all sectors, which is also reflected in the higher ratio of this indicator to Output in Figure 4. In the industry, the development of both ratio indicators can be assessed as balanced. In the case of the services, there is the increasing share of Compensation on Employees on Output compared to the slightly decreasing share of Consumption of Fixed Capital on Output.

The development in the case of the agricultural sector is rather specific, with oscillations until 2011 in both indicators, but in the following period there is an increase in the share of Consumption of Fixed Capital on Output, while at the same time the value of the share of Compensation on Employees on Output is lower. This is also reflected in the sharp increase in the mutual ratio of these two indicators, which indicates the increasing importance of fixed capital costs compared to personnel costs. It can therefore be assumed that in the agricultural sector there are investments in Fixed Assets, among which there are also investments in new technologies.

It is clear from the data in Figure 5, there is an increase in the Total Fixed Assets over the entire monitored period, both in its net concept and in its gross concept. Also identifiable is the period of the 1990s, when investment activity is higher, followed by a period of lower growth, which has increased again in recent years. Increases in ICT Equipment and Intellectual Property items for the entire Czech economy and at the same time for the industry and service are around 10%. Overall, a slight increase in the share of these components in the total value of Total Fixed Assets can also be seen in the entire Czech economy and at the same time in the industry and services. These data would therefore indicate that in the Czech economy there are investments in new technologies that can be connected with the Industry 4.0 initiative, especially with regard to the growth of the share of these components in the industry since 2011. On the other hand, there is no identifiable sharp year-on-year increase in those indicators during analyzed period that would indicate that this is a significant change in production processes neither in the industry nor in the service.

The agricultural sector appears to be specific again, while investments in ICT Equipment and Intellectual Property in agriculture decreased by 2010, which also resulted in a decrease in the share of these components in Total Fixed Assets. Since 2010, a significant growth of investments in this area can be seen. Although the share of ICT Equipment and Intellectual Property on Total Fixed Assets in Agriculture is still the lowest among all sectors, the dynamics of change have been more pronounced in recent years.

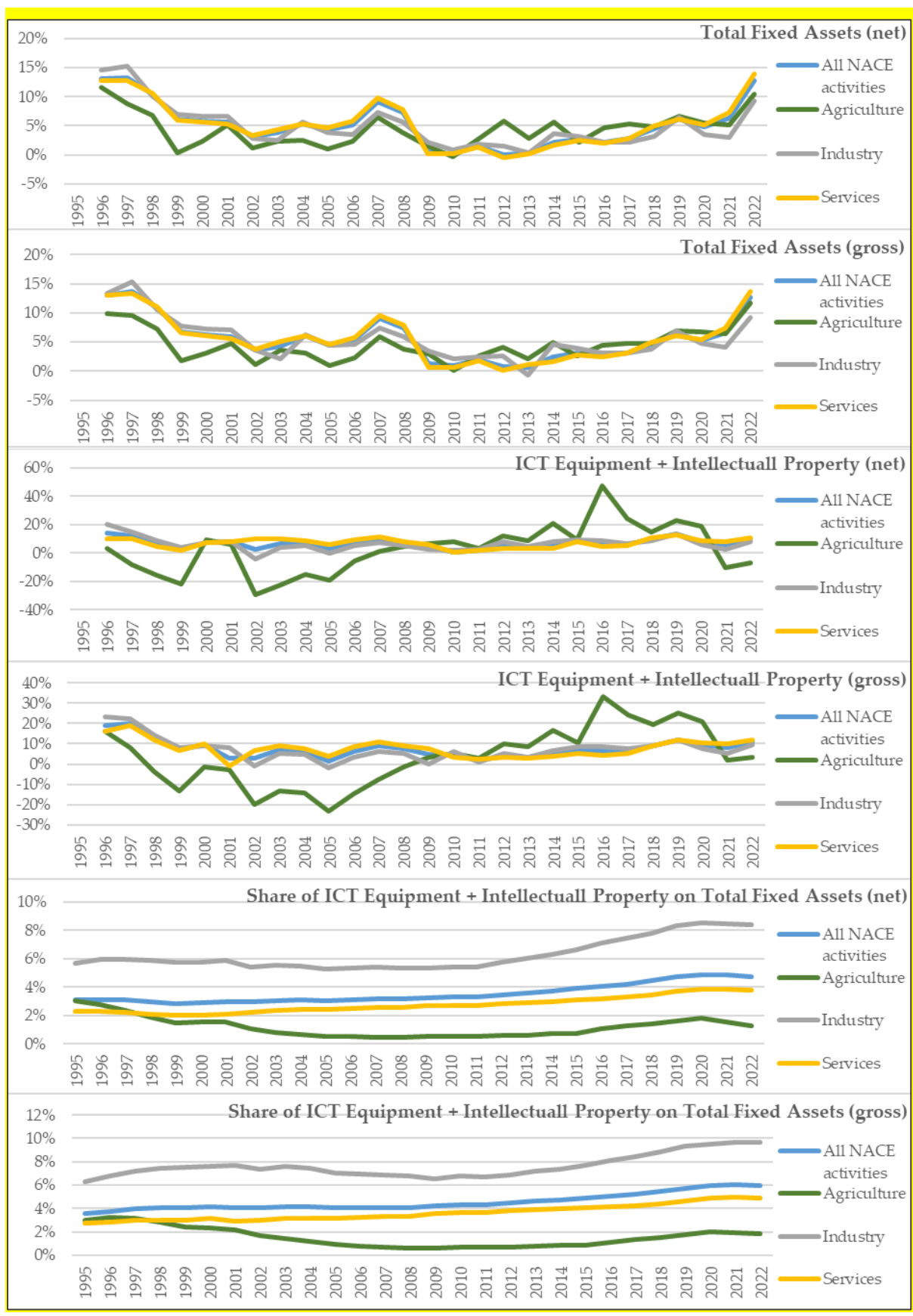


Figure 5. Development of year-to-year change of total fixed assets and selected component of fixed assets; development of ratio of selected components of fixed assets on total fixed assets

#### 4. Discussion

The results of the analysis correspond with other studies that identified the impact of Industry 4.0 on the economy, especially in labor productivity (Kurt, 2019; Trenovski et al., 2020; Grenčíková et al., 2020). These analyses indicate that as a result of the implementation of the Industry 4.0 initiative, there is an increase in labor productivity and an increase in the production capacity of the economy, reflected in GDP growth. The results also correspond to previous analyses, which indicated that the more significant impacts of the Industry 4.0 Initiative should be manifested in the agriculture (Marinič, 2022).

#### 5. Conclusions

The results of the analysis of selected economic indicators available from the Eurostat database indicate that in the conditions of the Czech economy in connection with the Industry 4.0 initiative, i.e. Agriculture 4.0, there are no radical changes in the production process. These findings therefore correspond with the previous analyses (Marinič & Pecina, 2021; Marinič, 2022) carried out. Even the current analysis indicates that the Czech economy is rather an evolutionary development, which is manifested in the increase of the production possibilities of the Czech economy, both from the point of view of the Output and from the point of view of the Gross Value-Added, through the evaluation of the given indicators in current prices even when valuing production at previous year prices. At the same time, there is a slight reduction in the number of hours worked per person. There are also investments in Total Fixed Assets with an increasing share of ICT equipment and Intellectual Property on Total Fixed Assets.

Considering that the previous analysis (Marinič, 2022) indicated the possibility of identifying the impacts of the implementation of the mentioned initiatives in the agriculture, the current analysis focused on that sector. The analysis shows that the agriculture in the Czech economy shows specifics in relation to the industry and services. It can be assumed that these specifics relate mainly to the transformation of the economy in the 1990s and the gradual decline in the importance of the agriculture from the point of view of the overall economy. On the other hand, the analysis suggests that the implementation of the impacts of the Industry 4.0 initiative, or Agriculture 4.0, really manifests itself in agriculture rather than in the industry or services.

Even though the agriculture lags the industry and services in many respects, from the point of view of the implementation of Industry 4.0, or Agriculture 4.0, it seems to be more successful than the other two sectors, especially according to the dynamics of increase of analyzed components of Fixed Assets since 2011, that can be assigned with the Agriculture 4.0, which create optimistic expectations for the future of agriculture in Czech Republic.

Conflict of interest: none.

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