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Article — Published Version

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Theoretical and Applied Economics

Suggested Citation: Tudorache, Maria-Daniela (2020) : Sustainable development in European Union as expression of social, human, economic, technological and environmental progress, Theoretical and Applied Economics, ISSN 1844-0029, Bucharest University of Economic Studies, Bucharest, Vol. 27, Iss. Special Issue - Economic Convergence in European Union Conference, pp. 191-204,
<http://www.ectap.ro/supliment/economic-convergence-in-european-union-eceu-17th-edition/32/>

This Version is available at:

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Sustainable development in European Union as expression of social, human, economic, technological and environmental progress

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Abstract. *This paper analyse the way how the sustainable developments components are interacting between them and reflects on a possible trade-off between social, human, economic, technological and environmental progress. In this context, I have computed the Pearson correlation coefficient between the mentioned forms of development for 2010-2018 period, but in some cases, my analysis was limited to a lower period due to the data availability. At all, I have concluded that social, human, economic, technological and environmental development are positively linked, but the link between technological and social development depends on the degree of automation which may spread certain social imbalances across the European Union on short-run. However, the link between social and technological development remain positive when it is assessed through the digitalisation channel or the growth of the IT&C sector.*

Keywords: development, social, economic, technology, environment, human, sustainable.

JEL Classification: O10, B55, A10, O14, O13, O15.

1. Introduction

Theory of development, in all its forms, associates the effects of well-being with progress, prosperity, emancipation and modernity. From this point of view, the theory of development is at the center of economic science, and the development process is the stake of mature societal strategies.

The European Commission has set out six priorities for the period 2019-2024, the first one being related to the transformation of Europe into a climate-neutral continent by 2050. In order to achieve this objective, Commission published its "Communication on European Green Deal", which highlights the measures needed for supporting the transition to a green economy.

Currently, one of the most provocative challenges that European Union is facing with consists in the climate change issues. In this regard, the "European Green Deal" will allow European citizens and businesses to benefit from a transition to a climate-neutral economy, as long as it becomes functional and takes into account the national specificities. The pact militate for reducing the greenhouse gas emission, investing in research, innovation and green technologies. Also, through the Annual Sustainable Growth Strategy 2020 (which is a part of the European Semester cycle), the European Commission sets the general priorities in the economic and employment field and places a special emphasis on sustainable development and social inclusion, as it has already been set out in the "European Green Deal", priorities that will guide the national reform plans and complement the efforts made at EU level to achieve the general objective of inclusive and sustainable growth.

The set of priorities identified in the Annual Sustainable Growth Strategy 2020 covers four interdependent dimensions, aimed at addressing the long-term challenges: (i) the environment; (ii) productivity; (iii) macroeconomic stability; (iv) fairness. As can be seen, the European Commission started to increase its focus on the need of an equilibrium between the social, economic and ecological dimensions. Within the strategy, technology is seen as a useful tool that can facilitate the achievement of many specific goals related to sustainable growth. However, some factors of technological development may also have adverse effects on some forms of development, such as social progress.

The reason for choosing the theme lies in the need for a unitary development at the European Union level, in the growing concern of the economists in this field, as well as in the existence of a potential trade-off between some forms of development, which requires the identification of a way to promote sustainable development.

The main objective of the paper is to identify the relations between the development forms at the European Union level, and the possible compromises between them. This can be achieved by reaching the following specific objectives:

- (a) identifying the relationship between technological development and other indicators relevant for development, as well as analysing the relationship between automation and economic growth;
- (b) identifying the relationship between automation and other factors relevant for development (including human, social and ecological development);

- (c) identifying the relationship between the share of households having access to internet and other factors relevant for development (including human, social and ecological development).

2. Literature review

The scientific literature in the field of development, its forms, as well that related to the interaction between these is very extensive, with many studies in this field. These include Smith (1869) who stated that progress, a significant aspect of civilization, spins around development towards urban, scientific and technological civilization. The author described four stages of civilization as follows: (i) hunting nations (the lowest status of society); (ii) shepherd nations (a more advanced state of society); (iii) agriculture; (iv) civilized and urban society.

On the other hand, Hoyle (1953) stated that civilizational development originates from a technological discovery - the discovery of agriculture. Further, the discovery of agriculture led to subsequent discoveries, such as the discovery of metal processing, which later led to many significant discoveries. Guizot (1997) remarked that civilization is the result of progress, development, and of the people going forward. Another opinion is that of Fagan (2008) who stated that climate change is the consequence of technological progress, which generated new threats for civilization.

Bowden (2016), highlighted that people cannot live outside a society, and a certain degree of socio-political cooperation and organisation is necessary for the foundation of civilization. Social and political progress appear before any form of progress, and all other forms of civilization are dependent on these. Moreover, Starobinski (1993) stated that civilization is an important factor in social development.

Regarding technological development, Solow (1974) proved that technological progress can support countries in overpassing the constraints that availability of natural resources exercise on economic growth. In this respect, technological progress ensures the possibility of switching from one resource to another, when the stock runs out, so as not to limit economic growth and to ensure long-term sustainability.

On the other hand, Grossman and Krueger (1995) stated that when countries records positive growth rates, environmental degradation grows until it reach a level, after that it begins to decrease and environmental quality starts on a positive path. The explanation is that in the early stages of the development process environmental degradation may be accepted as a side effect. However, after a certain level of economic well-being, people become more sensitive and willing to pay for improving the quality of the environment, by promoting/calling measures to remedy the effects of climate change.

Nordhaus (2008) affirmed that the problem of global warming can be solved by setting prices for environmentally harmful activities. Therefore, as global warming increases progressively, technological solutions that reduce greenhouse gas emissions should be introduced on the market. However, Malik (2012) stated that the decline of the environment is caused by the vast quantities of waste, the global growth of modern capitalism, huge

investments in technologies that do not take into account the environment, the corporate interests that aim to increase profits without taking into account by the impact on the environment, the governments that promote the interests of corporations and the consumerism.

As regards technological progress, Galbraith (2016) saw this process as a potential source for increasing income inequality, when qualifications are discriminated. Another argument is that, as a result of technological progress, the labour demand for workers who undertake a repetitive activity is diminished, given the possibility of technology to replace the service tasks provided in the respective field (Acemoglu and Autor, 2011) which also favors poverty and inequality. In addition, Jaumotte et al. (2008) have demonstrated that the increase of inequality and poverty from the last two decades was also a consequence of the technological progress. A solution for promoting sustainable development was provided by Jianu et al. (2019), who showed that improving the quality of institutions has the capacity to moderate income inequality and to allow an adequate level of wellbeing.

3. Methodology

In this paper, I analysed the relations between the forms of development, namely social, technological, economic, ecological and human development. For this purpose, I have used the analysis period 2010-2018. However, given the reduced availability of certain statistical data, I have also used the period 1996-2016 in the case of automation data (total operational stock of industrial robots, the number of industrial robots per thousand workers), respectively the period 2010-2016 in the case of other relevant indicators for development. In this context, I have used the Pearson statistical correlation, which I calculated according with the following formula:

$$\text{Pearsoncorrelation}(x, y) = \frac{\text{covariance}(x, y)}{sd_x sd_y}$$

$$\text{covariance}(x, y) = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{n - 1}$$

$$sd_x = \frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n}$$

where sd_x and sd_y represents the standard deviation of the select variable in European Union countries.

Therefore, I have calculated Pearson correlation in Panel window (using Eviews 9.0) at the level of EU-28, covering the same period at the level of each Member State.

The relationship between the development components was analysed using specific indicators for each form, (as shown in Table 1). Further, I have identified the development components that may exercise negative effects on other forms of development, this approach being used to check if there is a potential trade-off between these. In this context, the mentioned relationships were assessed in Eviews 9.0 software and Microsoft Office Excel using Scatterplot Graphs technique.

The analysis of the relationship between technological progress (which also involves automation) and other forms of development, such as economic, human, social and ecological development at EU level was carried out in four stages as follows:

1. general assessment of the relationship between technology (the share of IT&C value added in GDP/share of high-tech exports in total exports/share of households having access to internet) and other indicators relevant for development over the period 2010-2018;
2. analysing the correlation between the percentage change of the number of industrial robots and the economic growth, covering the period 1996-2016 at EU-28 level;
3. a. analysing the correlation between the percentage change of the number of industrial robots and other relevant factors for development (the percentage change of the greenhouse gas emissions, the share of households having access to internet/the share IT&C value added in GDP/the share of people exposed to poverty risks/the economic growth) over the period 2010-2016;
3. b. analysing the correlation between the share of households having access to internet and other relevant factors for development (the percentage change of greenhouse gas emissions/economic growth/percentage change of the number of industrial robots/the share of IT&C value added in GDP/the share of people exposed to poverty risks) over the period 2010-2016;
4. a. analysing the correlation between the percentage change of the number of industrial robots and the human development index and that between the share of household having access to the internet and the human development index in 2016 at EU-28 level;
4. b. analysing the correlation between the percentage change of the number of industrial robots and the people at risk of poverty rate and that between the share of households having access to the internet and people at risk of poverty rate in 2016 at EU-28 level.

It is worth mentioning that statistical the following indicators were not available for all Member States: the number of industrial robots, the number of industrial robots per thousand workers and the share of enterprises using industrial or service robots.

Table 1. *Data used*

Variable	Source	Relevant for
Human development index	United Nations	human development
Economic growth (%)	Eurostat	economic development
High-tech exports (% of total exports)	Eurostat	technological development
Households having access to internet (% of total households)	Eurostat	technological development
Informations, technology and communications value added (% of GDP)	Eurostat	technological development
People at risk of poverty rate (%)	Eurostat	social development
Unemployment rate (%)	Eurostat	social development and economic development
Percentage change of GHG emissions (thousand tonnes) all sectors	Eurostat	ecological development
Total operational stock of industrial robots	Bruegel, IFR	technological development
The number of industrial robots per thousand workers	Bruegel, IFR	technological development
The share of enterprises using industrial or service robots (% of total enterprises)	Eurostat	technological development

Source: Own processing using Microsoft Office 2016.

4. Results and interpretations

Sustainable development is an extremely important process at global level and should be promoted through appropriate policies having the objective to facilitate an equilibrium between the following dimension: social, economic, technological, environmental and human. According to the methodology used and to the results of the correlation between economic, human, technological and social development, I have demonstrated that these are positively correlated (Table 2). In this respect, I found a high negative correlation between people at risk of poverty rate and the share of households having access to internet of -47.0% in EU-28. The internet access rate at household level is also negative correlated with the evolution of unemployment rate -44.3%, these evidences signalling the higher capacity of internet use to provide more economic opportunities for population and to reduce unemployment and the number of people at risk of poverty. In addition, these evidences also prove a potential positive link between digital transformation and social development. In line with these results, I have also found a negative correlation between the share of IT&C value added in GDP and people at risk of poverty rate, which creates the premises of the existence of an inverse relationship between these variables, since, the higher is the value added generated by this sector, the lower is the unemployment, this driving the poverty falling down.

However, the negative correlation between the share of households having access to internet and the people at risk of poverty rate is higher than the one between the share of IT&C value added in GDP and poverty rate (-12.1%), which indicates the possibility of a negative impact exercised by a technological development factor on poverty rate, such as automation. Regarding the share of high-tech exports in total exports, it is also positive linked with economic growth (31.0%), human development index - HDI (38.0%), the rate of access to internet (81.6%), the share of IT&C value added in GDP (29.4%), but also negative linked with unemployment and poverty. Besides that, economic growth and HDI are positive linked with analysed components of technological development and social progress (reduction of poverty and unemployment).

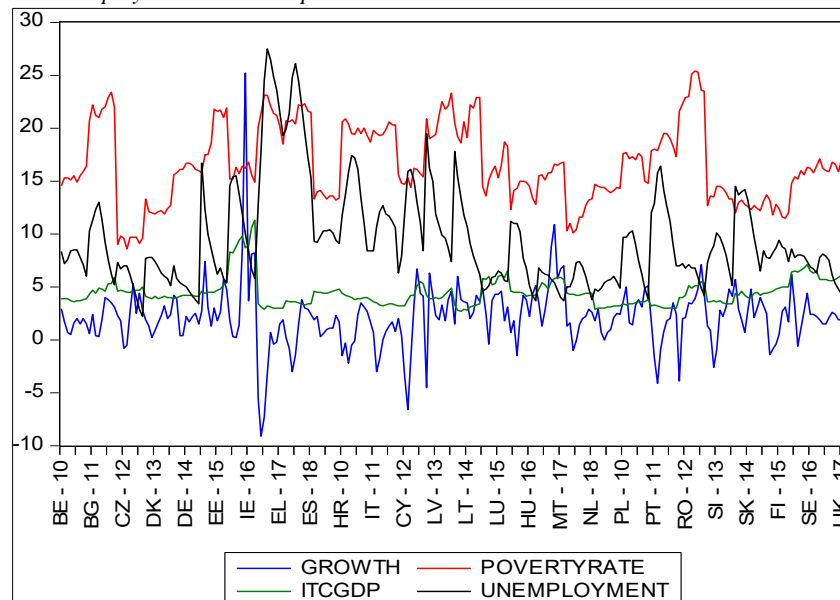
Table 2. *The correlation matrix between the relevant indicators for development in the period 2010-2018 (Panel Pearson correlation)*

Correlation matrix 2010-2018 (EU28 MS)	Economic growth (%)	Human Development Index (HDI)	High-tech exports (% of total exports)	Households having access to internet (% of total households)	Informations technology and communications value added (% of GDP)	People at risk of poverty rate (%)	Unemployment rate (%)
Economic growth (%)	1.000	0.098	0.310	0.292	0.392	-0.044	-0.348
Human Development Index (HDI)	0.098	1.000	0.380	0.816	0.294	-0.523	-0.339
High-tech exports (% of total exports)	0.310	0.380	1.000	0.437	0.589	-0.422	-0.443
Households having access to internet (% of total households)	0.292	0.816	0.437	1.000	0.352	-0.470	-0.498

Correlation matrix 2010-2018 (EU28 MS)	Economic growth (%)	Human Development Index (HDI)	High-tech exports (% of total exports)	Households having access to internet (% of total households)	Informations technology and communications value added (% of GDP)	People at risk of poverty rate (%)	Unemployment rate (%)
Informations, technology and communications value added (% of GDP)	0.392	0.294	0.589	0.352	1.000	-0.121	-0.246
People at risk of poverty rate (%)	-0.044	-0.523	-0.422	-0.470	-0.121	1.000	0.399
Unemployment rate (%)	-0.348	-0.339	-0.443	-0.498	-0.246	0.399	1.000

Source: Own calculations using Eviews 9.0, Eurostat and United Nation database.

Figure 1. The evolution between economic growth, poverty rate, ITC value added in GDP and unemployment rate in the period 2010-2018



Source: Own processings using Eviews 9.0, Eurostat database.

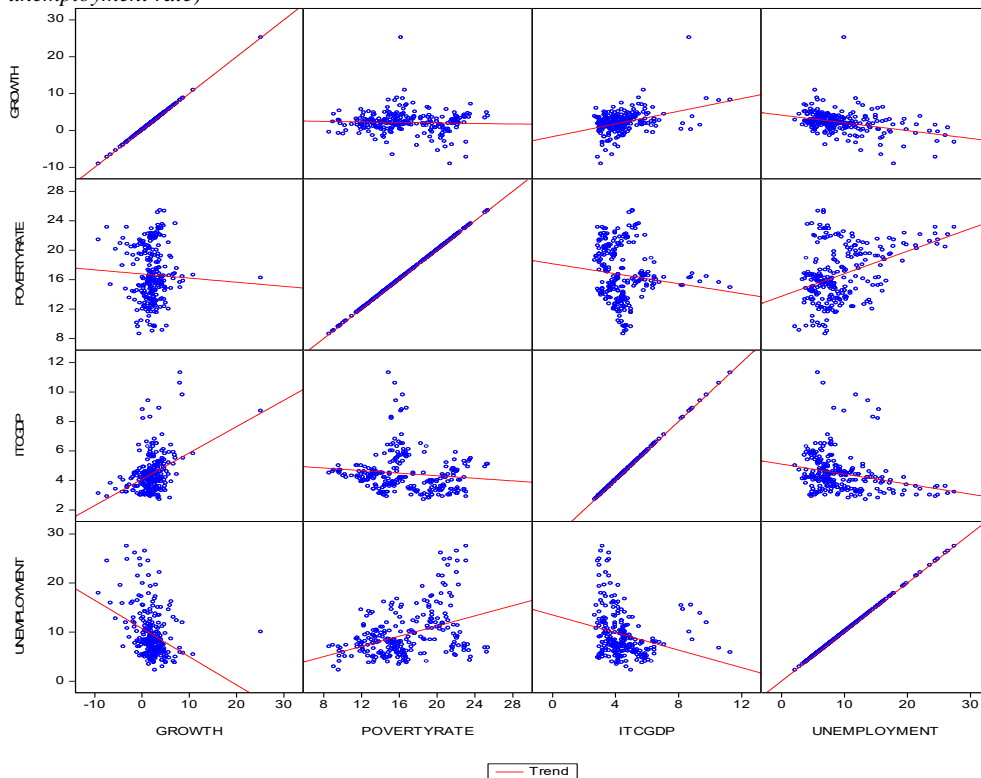
Moreover, I have found a high correlation between the economic growth rate and the added value of the ICT sector - expressed as a percentage of GDP (39.2%) at EU-28 level, which can also be visualised in Figure 1. However, there is a negative relationship between economic growth and the people at risk of poverty rate (-4.4%), as well as between economic growth and unemployment rate (-34.8%).

I have also checked the relationship between economic growth, unemployment rate, poverty rate and the share of IT&C value added in GDP by analysing the correlation matrix scatterplot generated following the computation of EU-28 panel data series over the 2010-2018 period (including the data for all Member States for each series). In Figure 2, a strong correlation between the added value of the IT&C sector in GDP and the economic growth is visible. This is a consequence of the fact that IT&C sector boost the economic growth,

through jobs, investment, digitization, and automation. I have also found, a positive relationship between poverty rate and unemployment rate, given that people in unemployment make low incomes and are more likely to fall into the category of people at risk of poverty than employees. On the other hand, another negative correlation was reported in the case of the relationship between the poverty rate and the share of IT&C value added in GDP, as was demonstrated in the first part of the analysis when I used the data reported for EU-28 time-series.

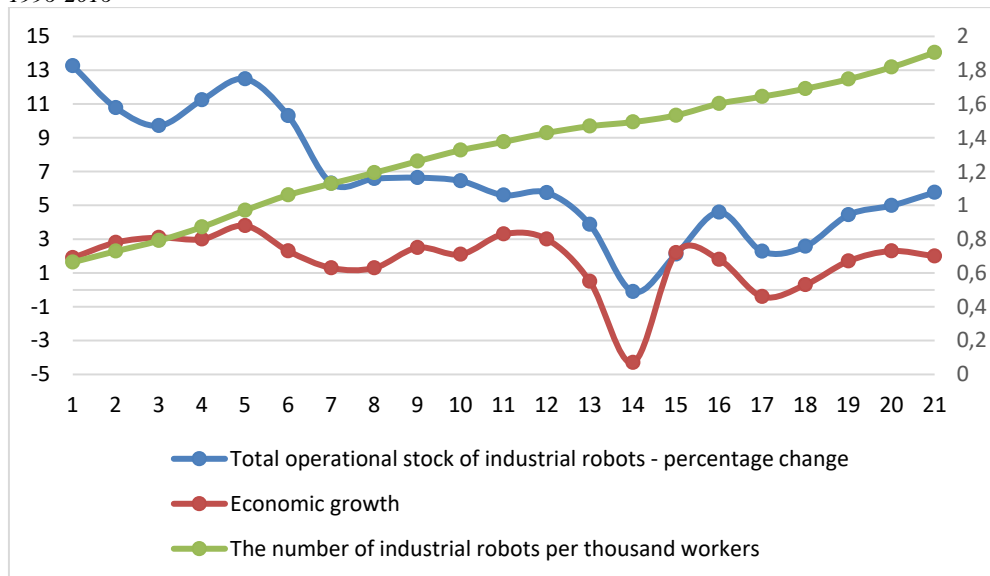
Figure 3 shows the evolution of three indicators in the European Union between 1996 and 2016 (statistical data for a longer period were not available): the percentage change of the number of industrial robots, the economic growth and the number of industrial robots per thousand workers. As can be seen in the graph, the percentage change in the number of industrial robots is evolving in the same direction with the economic growth, which shows a strong positive relationship between automation and economic growth at European Union level. It can be also observed the shock caused by the economic crisis at the level of both indicators. However, the robot density continued its progressive path, given that the number of industrial robots increased with lower rates compared to the occupied population, which steadily decreased, especially during the economic crisis, when unemployment reached extreme levels.

Figure 2. Scatterplot matrix (economic growth, poverty rate, share of ITC value added in GDP and unemployment rate)



Source: Own processings using Eviews 9.0, Eurostat database.

Figure 3. The relationship between percentage change of total operational stock of industrial robots, economic growth and the number of industrial robots per thousand workers in European Union (28 MS) in the period 1996-2016



Source: Own processings using Eurostat and Bruegel, IFR reports.

Table 3. The correlation matrix between the relevant indicators for percentage change of total operational stock of industrial robots in the period 2010-2016

(Panel Pearson correlation)

Pearson correlation	Percentage change of GHG emissions (thousand tonnes) all sectors (%)	Economic growth (%)	Percentage of households having access to internet (%)	Informations, technology and communications value added (% of GDP)	People at risk of poverty rate (%)
Percentage change of total operational stock of industrial robots (%)	0.246	0.948	0.541	0.915	0.406

Source: Own calculations using Eviews 9.0, Eurostat and Bruegel, IFR database.

Next, I analysed the correlation between the percentage change of the number of industrial robots in the European Union and the relevant indicators for development. According to the Table 3, the number of industrial robots is positively correlated with the percentage change in the greenhouse gas emissions, economic growth, the share of households having access to internet, the share of IT&C value added in GDP and the poverty rate. The strongest correlation was reported between the percentage change of total number of industrial robots and economic growth (94.8%), respectively between the first mentioned indicator and the share of IT&C value added in GDP (91.5%). Industrial robots replace employees in the labour market activities and optimize the production process, as it increase the speed and efficiency of this process, which have a positive impact on the economy. Moreover, the increase of the percentage change in the number of industrial robots is favorable to the growth of IT&C sector. However, robotics may have also negative effects on social development, since it increase the number of people exposed to poverty through the channel of unemployment, which demonstrates the need to parameterize the trends in

automation. From another perspective of technology, Table 4 shows a positive relationship between the percentage of households having access to internet with all analysed indicators, excepting poverty rate, which was also analysed above over a longer period. In this case, the strongest correlation was registered between the share of households having access to internet and the percentage change of greenhouse gas emissions (56.8), which shows that certain factors of the technology favor harmful change of the environment/climate. Climate change is a serious issue at global level which negatively impact our lives on long-run.

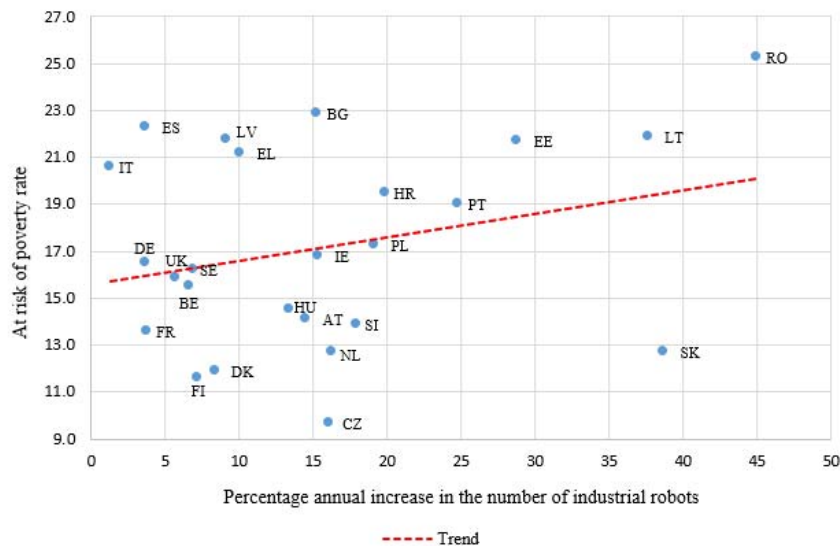
Table 4. The correlation matrix between the relevant indicators for percentage of households having access to internet in the period 2010-2016 (Panel Pearson correlation)

Pearson correlation	Percentage change of GHG emissions (thousand tonnes) all sectors (%)	Economic growth (%)	Percentage change of total operational stock of industrial robots (%)	Informations, technology and communications value added (% of GDP)	People at risk of poverty rate (%)
Percentage of households having access to internet (%)	0.568	0.464	0.541	0.391	-0.189

Source: Own calculations using Eviews 9.0, Eurostat and Bruegel, IFR database.

Figure 4 shows the positive but not strong relationship between the percentage change in the number of industrial robots and the poverty rate. The automation of the production processes leads to the increase of the poverty rate, by reducing the number of jobs or of the highly paid ones. The Member States facing the highest levels of poverty rate are RO, BG, ES, LV, LT. On the other hand, even if it is facing the highest level of poverty, RO had the highest increase in the number of industrial robots (45%) in 2016, followed by SK and LT. It can also be observed that the European Union countries are very dispersed from the trend, the furthestmost from it being CZ, SK, RO, BG and ES. Among these countries, the most correlated evolution between automation and poverty rate is shown in Romania, followed by HR, EE and LT.

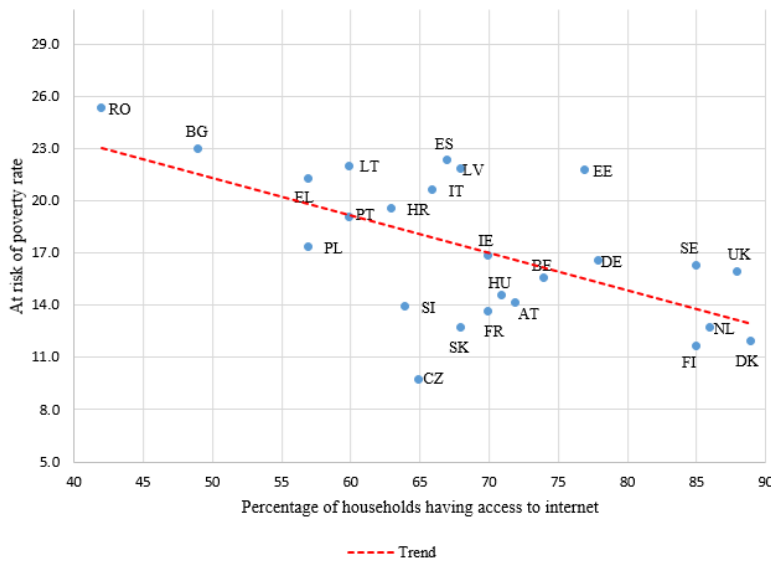
Figure 4. The relationship between percentage change of total operational stock of industrial robots and people at risk of poverty rate in 2016



Source: Own processings using Eurostat and Bruegel, IFR reports.

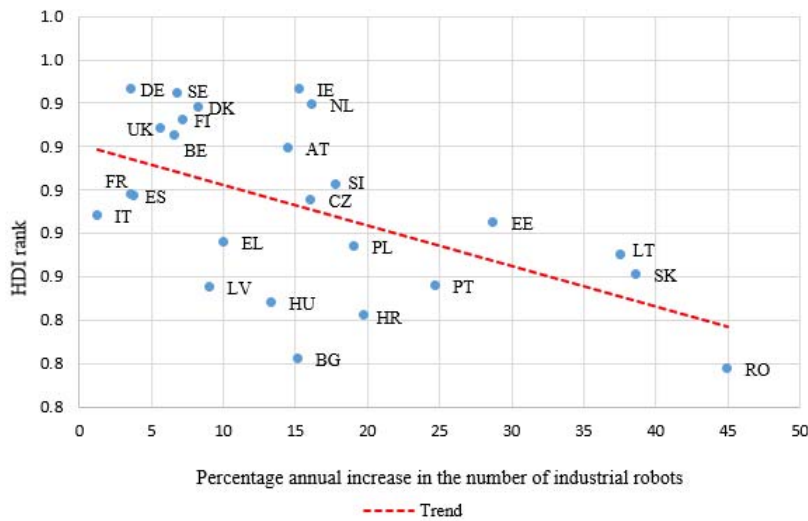
On the other hand, Figure 5 shows a high negative correlation between the internet access and poverty rate. In this situation it can be seen that access to the internet, respectively access to information, leads to poverty reduction. RO and BG are the states with the fewest households connected to internet in relative terms. Member States are closer to the trend (with the exception of CZ), which indicates a better convergence at the level of EU from the perspective of the link between the mentioned variables.

Figure 5. The relationship between percentage of household having access to internet and people at risk of poverty rate in 2016



Source: Own processing using Eurostat and Bruegel, IFR reports.

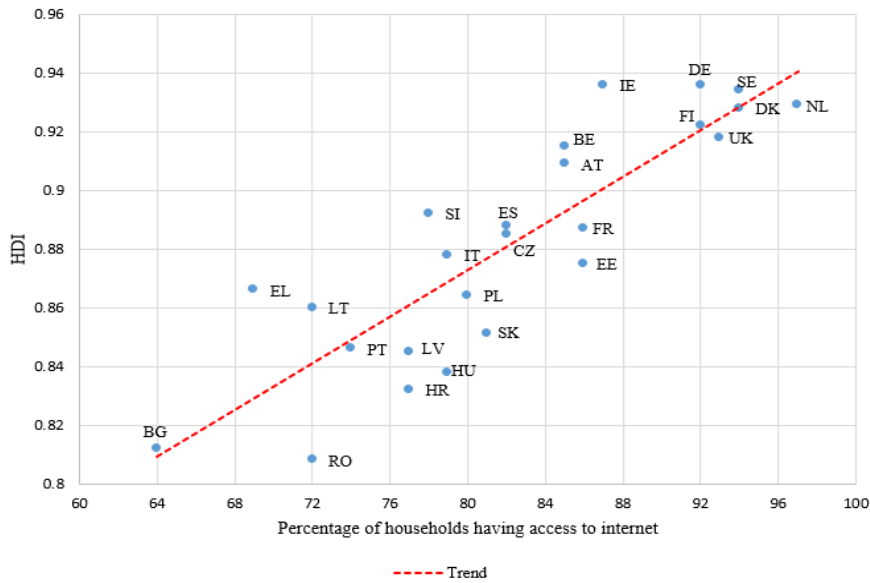
Figure 6. The relationship between percentage change of total operational stock of industrial robots and human development index in 2016



Source: Own processing using United Nations and Bruegel, IFR reports.

Further, in Figure 6, I have analysed the relationship between the percentage change in the number of industrial robots and the human development index, where a strong negative correlation was identified. The most diverging countries from the trendline are IE, BG, HU and NL, but the overall correlation indicates a strong inverse relationship between automation and human development.

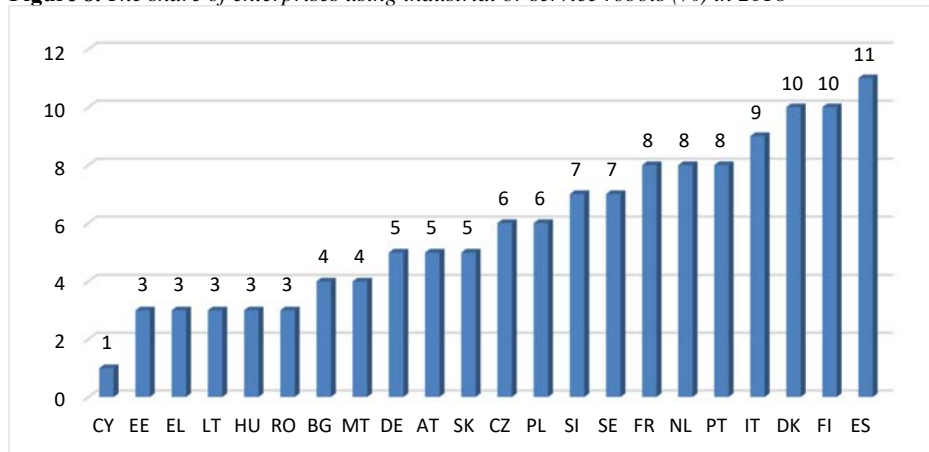
Figure 7. The relationship between percentage of household having access to internet and human development index in 2016



Source: Own processing using United Nations and Bruegel, IFR reports.

Figure 7 shows a strong positive correlation between the percentage of households with internet access and the index of human development. In this case, all countries are strongly correlated, which argues the importance of access to information for the human development process.

Figure 8. The share of enterprises using industrial or service robots (%) in 2018



Source: Own processing using Eurostat database.

Finally, Figure 8 shows the position of certain Member States as regards the share of enterprises using industrial or service robots in total enterprises. Due to the fact that Eurostat published the dataset for this indicator only for 2018 year, there are still missing data for other countries such as BE, IE, HR, LU, LV and UK. As shown in the graph, the countries with the highest share of robots used in industry and services are ES (11%), followed by DK and FI (10% each). On the other hand, at the opposite pole is CY (1%), followed by EE, EL, LT, HU and RO (3% each).

All analysed data demonstrate that there is a possible trade of between automation and social development, but also between automation and human development, even if other factors of technological progress favor the other forms of development. This study also proves that automation is negatively linked with environmental development in some cases but this relationship needs to be further explored to increase the robustness of the evidences.

5. Conclusions

This study shows that technological progress favors other forms of development, namely social development, human development and economic development, excepting the environmental development. However, even if, generally, technology is well-being friendly, some of its components, such as automation, are detrimental to human and social development, which argue the need to parameterize the technological progress, in order to promote sustainable development.

In this context, this study identifies a positive relationship between the number of industrial robots and poverty rate, given that industrial robots replace the low-skilled workforce and increase the poverty risks for people facing unemployment. At the opposite, there is also a negative relationship between the rate of households having access to the internet and the poverty rate, which shows that low access to information affects the standard of living of citizens. Moreover, I have also found that the increase in the number of robots leads to a decline in the human development index. On the other hand, I have found a positive relationship between the rate of households having access to the Internet and the human development index, which creates the premise that access to information favors the development of individuals.

As regards the link between technological and environmental development, this paper also shows that there is an inverse relationship between automation and ecological development, given that the three industrial revolutions has favored the challenges we are facing today related to climate change. Nevertheless, an exhaustive analysis on this relationship is needed to identify the most appropriate solutions to adjust the relationship in positive way.

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