Problems and prospects for the development of 5G technologies in the modern economy: case study of Germany and the Netherlands

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Abstract. The active introduction of 5G technologies in the countries of North-East Asian countries, Europe and the United States is due to the expected direct and indirect effects on the economy and social sphere. Nowadays, they implemented in agriculture, healthcare, industrial production, media, and financial services. The deployment of 5G networks has its own specifics, requires a certain infrastructure and administrative support. The article assesses the problems these countries often face when implementing 5G technology, and determines the prospects for their development in terms of the modern economy. The leading countries in technological development in the European Union – Germany and the Netherlands – have been identified as the object of the study. The article uses a mixed approach to research: SWOT analysis, assessment of the multiplier effect on economic development (GDP growth) and the labor market (creation of new jobs) when implementing 5G technologies. To understand the current state of 5G implementation in Germany and the Netherlands, strengths were identified, such as general economic dynamics, tax support, and growing demand. Among the problem areas, an imbalance of the labor market was revealed – unemployment in Germany, a shortage of labor resources in the Netherlands, dependence on the common policy of the European Union, rising inflation, interest rates, and others. The determination of the direct effect showed that the multiplier value is much higher in small countries, that is, they will receive the maximum effects from investments in 5G technologies. Whereby, the large countries achieve a high absolute increase in GDP and employment.

Keywords: 5G technologies, mobile operators, the impact of 5G on the economy, SWOT analysis, multiplier effect the impact of 5G technologies on economic development, Germany, the Netherlands

JEL codes: O11, O14, O32

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Introduction

At the certain stages of their development, information and communication technologies (ICT) played an important role in the economy and social sphere. Countries which ealier introduced current forms of ICT gained an undoubted competitive advantage in the international market. Today, 5G technologies are becoming a new economical element, which have a great deal of responsibility. They provide a higher quality of user service, flexible infrastructure, a high level of security and reliability (Vlaskina, 2022). New technologies affect the economy and society through the expansion of communication capabilities on various platforms and the transformation of industrial sectors based on the use of big data (Allam, 2020).

Moreover, 5G technologies are able to provide platforms and networks for Industry 4.0 (Attaran, 2023). They contribute the Internet of Things and communication services mainstreaming (GSMA, 2017). Their wide application is expected in the media and entertainment sector, in manufacturing and trade, the creation of reliable cars, logistics, transportation, medicine, the development of smart cities, energy, etc.

Primarily, 5G technologies fulfil the 9th UN Sustainable Development Goal – creating sustainable infrastructure, promoting sustainable industrialization and stimulating innovation. They also form competitive opportunities for labor resources (Rastvortseva et al., 2008), income generation in industry, trade

(Prokushev & Kostin, 2022), the service sector, promote the introduction and innovations. In addition, the use of 5G technologies in daily life contributes to the implementation of the 11th Sustainable Development Goal. Namely, the establishment of «inclusive, safe, resilient, sustainably developing cities», which become drivers engines of the future economic growth.

5G technologies allow us the more effective production processes automation. They can be implemented in the service sector, which makes them a strategically important priority at the national level. The COVID-19 pandemic reveals the crucial role of mobile technologies, new business models for companies and new digital solutions for consumers. According to forecasts, by 2030, the change in economic processes due to the use of 5G technologies will contributes to the European economy an additional €102 bn per year[1].

In the economy of cities, technologies provide the development of new forms of transport services, including autonomous vehicles, regulation based on sensors and cameras. The high speed of information transmission makes it possible to ensure the safety of life in cities and regions, supports the work of emergency services, etc. 5G technologies are also used in the preservation of cultural heritage, allow ones to create virtual analogues (Di Giulio et al., 2019) and broadcast them widely.

The purpose of the study is to identify problems and prospects for the 5G technologies development in the modern economy. Two European countries, leaders in terms of technological development – Germany and the Netherlands – are the objects of the research.

At the first stage of the research we present the its theoretical aspects; show the importance of the 5G technologies development for the economy and social sphere. At the second stage we consider the appropriate methods and sources of statistical information. Results show the main trends in the 5G technologies development in the European Union and, using the example of Germany and the Netherlands, we will identify the strengths and weaknesses of the technological development process. There is also the assessment of the multiplicative effect of the 5G technologies impact on the economic development, namely, GDP growth and the number of employed, for the countries of the European Union. Conclusion presents some promising areas of its development.

The assessment of the economic benefits for countries and regions in terms of the introduction and operation of 5G technologies is considered from several points of view. One of the directions is the Internet of Things – the unhindered exchange of data generated by sensors, cameras, smartphones and other devices (Edler, 2019). Its implementation makes possible the development of industries related to GPS navigation, the movement of public and personal transport, emergency services, monitoring of cities economic services, certain service flexible switching on and off, etc. Moreover, PwC (2021) research reveals the impact on five areas: healthcare, smart home technologies, media, industrial production, and financial services.

There are a lot of studies concerning with the issue that 5G technologies can provide significant benefits in agriculture through the use of sensors and other monitoring devices to control plant growing, determine soil, and forecast weather conditions. For example, the Chinese company China Mobile launched the 5G + Smart Agriculture program, which uses 5G technologies to assess and analyze the fields and crops items (China Mobile, 2021).

An analysis of the effectiveness of the 5G technologies implementation conducted also for the healthcare system. According to it, innovations help to conduct consultations remotely, operate, contribute to a better understanding of the situation, as they operate the large volumes of medical information for the diagnosis and treatment of patients. The Smart Health project is being implemented in Italy today, where 5G is used for remote diagnosis and treatment of stroke patients (TIM Research Centre, 2020). This approach increases the efficiency and quality of medical care.

A whole block of research addresses the feasibility of implementing 5G technologies. For example, the need for more frequent placement of communication towers calls into question the safety for public health (Kostoff et al., 2020). There are also some problems with the use of 5G technologies in the industry (Ericsson, 2017). First of all, it is the high cost of network deployment. The analysis of the European Commission

[1] *GSMA Association. The Mobile Economy Europe 2021. https://www.gsma.com/mobileeconomy/wp-content/uploads/2021/09/GSMA_ME_Europe_2021_R_Web_Singles.pdf (accessed 10.05.2023)*

showed that the deployment of 4G in the EU member states cost 135 euros per subscriber. According to investment estimates, in 2025, the cost of deploying 5G will be 145 euros per subscriber. Hence, the total cost of implementing 5G technologies in the EU will be approximately €58 bn by 2025 (European Commission, 2016).

Methods

The importance of 5G technologies for the modern economy is realized in many countries of the world. The prospects of modernizing business models, increasing the level of competitiveness, and the quality of life are the purposes of introducing and distributing 5G technologies. The long term imbalance of technological development may aggravate the problem of inequality of countries (Rastvortseva et al., 2014). However, the countries availability to transition to a new level of technology varies. The countries of Asia and the United States have made more progress in this field (Fig. 1).

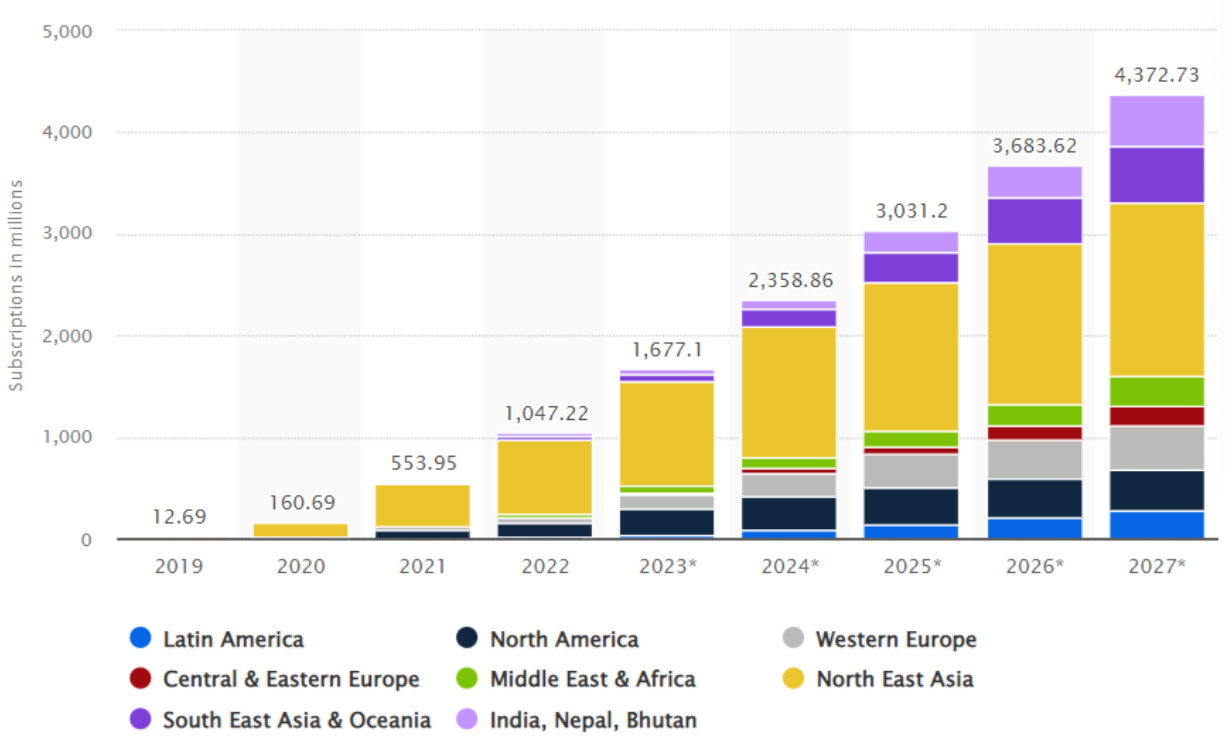


Figure 1. Forecast number of mobile 5G subscriptions worldwide by region, 2019-2027 (in millions)
Source: Ericsson. (November 1, 2022). Forecast number of mobile 5G subscriptions worldwide by region from 2019 to 2027 (in millions). https://www.statista.com/statistics/521598/5g-mobile-subscriptions-worldwide (accessed 02.05.2023).

The worldwide number of subscriptions to 5G mobile communications in 2019 amounted to 12.69 mln units, increasing to 1677.1 mln units by 2023. According to forecasts, in 2027 the number of subscriptions will amount to 4372.73 mln. A significant share of 5G subscriptions is in Northeast Asia[2] (in 2019 – 77.5%; in 2023 – 61.4%; according to forecasts in 2027 – 39%).

To assess the actual state of the 5G technologies development, prospects, external environment, factors, and conditions on case study of two leading countries Germany and the Netherlands, we propose to use a modification of SWOT analysis, which involves dividing all conditions into four groups: (SO) – strengths that represent development opportunities; (WO) – weaknesses, overcoming which will allow the country to get additional opportunities; (ST) – strengths that may become a threat in the future and require special attention; (WT) – weaknesses that pose a threat to development.

However, to assess the multiplicative effect of the 5G technologies impact on the social and economic spheres, we will use the approach of the European Commission (European Commission, 2016). This

[2] *The Northeast Asia region includes China, North and South Korea, Japan, and Mongolia. It accounts for a fifth of the world's population, a quarter of the world's GDP (according to: Political issues and peace-building issues UN). https://dppa.un.org/ru/northeast-asia (accessed 10.05.2023)*

technique determines the direct effect, which arises directly from investments into 5G infrastructure and the indirect impact of the first type (Type I multiplier effect). It is measured by an increase in production and an expansion of the number of services provided in the field of operating systems and ensuring the operation of 5G networks.

$$Type\ I\ Multiplier = \frac{Direct\ Effect\ +\ Indirect\ Effect}{Direct\ Effect} \quad (1)$$

it includes *Direct Effect* and *Indirect Effect*.

The induced effect (Type II multiplier effect) reflects changes in consumer spending and consumption of goods and services as a result of an increase in household income.

$$Type\ II\ Multiplier = \frac{Direct\ Effect\ +\ Indirect\ Effect\ +Induced\ Effect}{Direct\ Effect} \quad (2)$$

The effect of direct, indirect, and induced effects is shown in Figure 2.

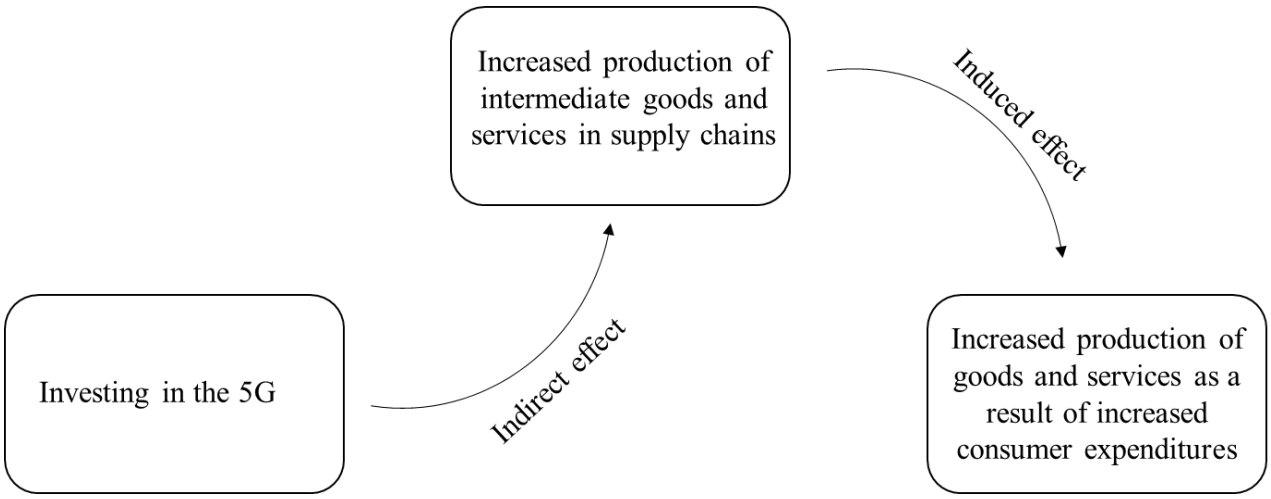


Figure 2. Direct and indirect effects of the 5G implementation

Source: composed according to the European Commission. Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe. https://op.europa.eu/en/publication-detail/-/publication/2baf523f-edcc-11e6-ad7c-01aa75ed71a1/language-en. (accessed 12.05.2023)

An Input-Output analysis is used to assess the economic benefits from the implementation of technologies (European Commission, 2016).

The Input-Output Analysis a qualitative tool for assessing the impact of the new technologies implementation on various sectors of the economy (Christ, 1955). It also can be used for decision-making in economics and business. Input-output tables give a quantitative idea of the interdependencies between different sectors of the national economy. Indirect and induced effects are calculated using input-output tables as follows:

$$L = (I - A)^{-1}, \quad (3)$$

where

L is the inverse Leontiev matrix, the matrix of direct material costs;

A is a matrix of technological coefficients calculated by dividing each cell of the intermediate internal supply by the total industry supply;

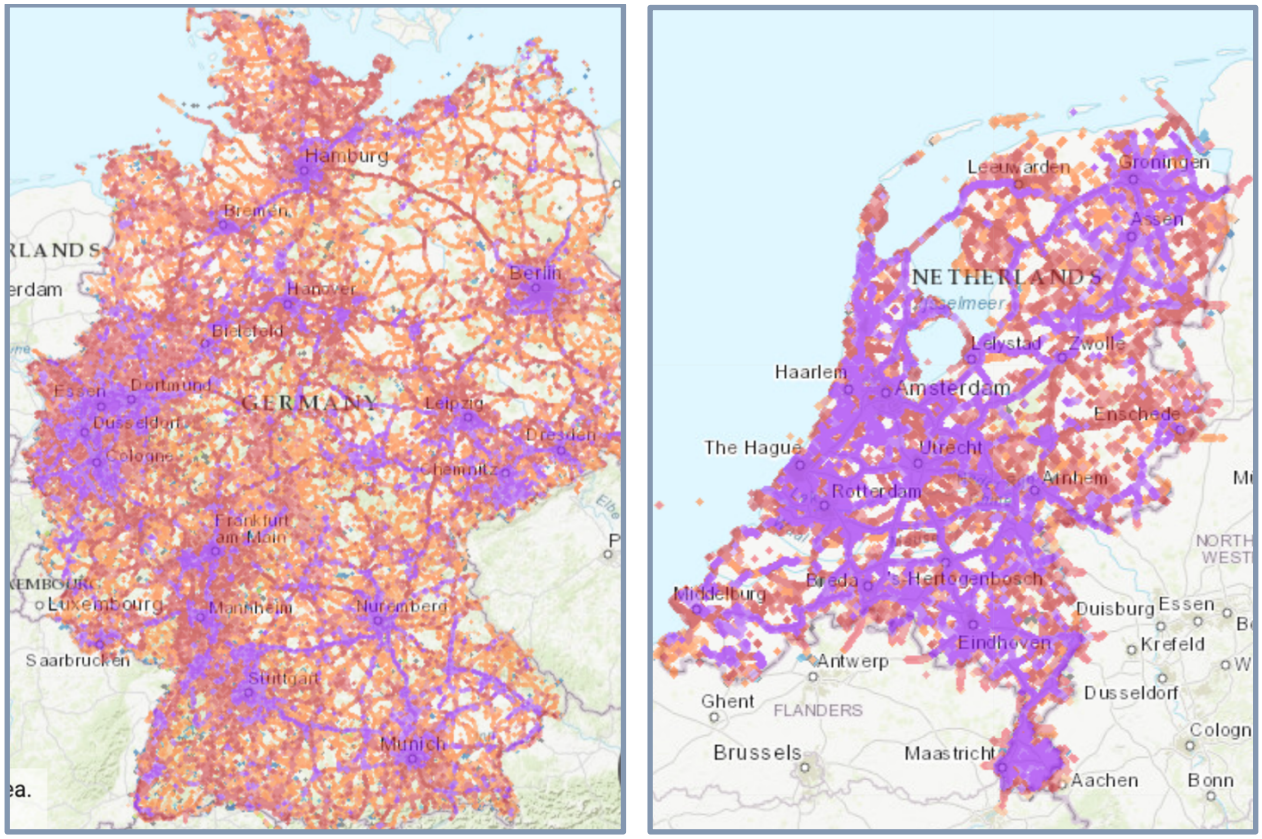
I is a unit matrix.

The databases of the World Bank, the European Commission, the Organization for Economic Cooperation and Development of the nPerf's objectives and GSMA news agencies, statistical databases Statista, Trading economics, EuroStat, WIPO publications and others served as sources of statistical and analytical data.

Results: analysis of the actual state and prospects for the 5G technologies development in Germany

and the Netherlands

Nowadays, Germany is one of the leading countries in Europe in terms of the 5G technologies implementation. 5G networks are deployed in all large and medium-sized cities. According to this indicator, Germany ranks world's 8th. However, in 2022, 58 cities had access to 5G mobile networks[3]. Currently, a significant part of the Netherlands territory is equipped with antennas providing connection to 5G networks, while 4G mobile networks still remain predominant. 4G and 5G mobile network coverage is shown in Figure 3.



a) Germany b) the Netherlands

Figure 3. 4G and 5G mobile network coverage map in Germany, (red – 4G, purple – 5G)
Source: https://www.nperf.com/en/map/DE/-/-./signal / (accessed 05.05.2023)

We used a SWOT analysis matrix for a more detailed reviewing of the problems and prospects of implementing 5G in Germany and the Netherlands (Fig. 4).

SO.G1, SO.N1. The high level of GDP per capita indicates the country has sufficient resources to invest in 5G and the development of corresponding infrastructure (Fig.5). In general, GDP is higher in Germany. Therefore, the need for new networks for economic development may be higher. GDP per capita is higher in the Netherlands. Therefore the demand from a more affluent population for new technologies can be rather higher.

The dynamics of GDP and GDP per capita as a whole are positive. A certain decline was observed in the overall indicator in 2020 due to the COVID-19 pandemic. In total GDP, this decline was not significant. During the analyzed period in Germany there was an increase of 9.06% (or 1.01% on average per year), in the Netherlands – 12.99% (or 1.44% per year). Per capita growth in Germany was 7.22% (or 0.8% per year), in the Netherlands – 13.45% (or 1.49%). In general, the volume of German GDP is four times higher, but in per capita terms it is lower (about 90%).

[3] *Number of cities in which 5G is available 2022 by country. Statista. https://www.statista.com/statistics/1215456/5g-cities-by-country (accessed 13.03.2023).*

Strengths (S)	Weaknesses (W)	
Germany **SO.G1**. High level of GDP, constant growth trend – 1% per year, per capita GDP growth by 0.8% per year **SO.G2**. Growth of the households with Internet access **SO.G3**. Support for mobile operators **the Netherlands** **SO.N1.** High level of GDP per capita with growth of 1.45% per year, GDP growth of 1.44% per year **SO.N2.** High Global Innovation Index ranking (2nd place in 2022) **SO.N3.** Tax benefits and preferences for R&D companies (all forms of support) **SO.N4**. Growth of the households with Internet access	**Germany** **SW.G1.** Dependence on EU policy in the field of 5G technology development **SW.G2.** Decrease in the number of patent applications in EPO in the digital communications field **SW.G3.** Rising unemployment rate **SW.G4.** Place in the top 10 in the ranking on the Global Innovation Index, growth **the Netherlands** **SW.N1.** Labor shortage, high level of vacancies	Features (O)
Germany **ST.G1.** High level of access to 4G mobile networks **ST.G2.** Significant progress in the deployment of Very High Capacity Networks (VHCN) **ST.G3.** In terms of the tax incentives, there are the tax credit and R&D grants only **the Netherlands** **ST.N1**. Expanding the frequency range for 5G deployment **ST.N2.** Growth in the total number of patent applications in EPO	**Germany** **WT.G1**. Rising inflation rate **WT.G2.** Rising interest rates in the EU **the Netherlands** **WT.N1.** Rising inflation rate **WT.N2**. Rising interest rates in the EU **WT.N3.** Low share of government spending on R&D	Threats (T)

Figure 4. The results of the SWOT analysis of the conditions for the 5G technologies implementation in Germany and the Netherlands

Source: composed by authors

SO.G2, SO.N4. The share of households with broadband Internet access is growing (Fig. 6). Indeed, the level of Internet use among individuals in both countries remains high (Fig. 6). Meanwhile, these trends can be defined as the strengths, which will determine the future socio-economic development.

In the Netherlands households used the Internet more actively throughout the analyzed period. While in the Netherlands over 90% of households are already connected to broadband Internet, in Germany it is only three-quarters of them.

ST.G2, ST.N1. Indeed, a significant progress has been made in Germany in the deployment of VHCN. In 2019, the share of connected households increased significantly when 5G connectivity was launched in Bonn and Berlin. At the same year, the share of connections in the Netherlands also increased due to the deployment of VHCN networks. The country occupies a leading position by this indicator in the European Union.

SO.N2, SW.G4. The rating of the Global Innovation Index is designed to assess the quality of the world countries development by a number of innovative indicators, availability to use innovations, resource, and resultant components of technological progress. 5G technologies are the basis for the high-tech projects and

new infrastructure development. Therefore, in general, an environment effective for innovations is extremely important for their effective implementation. The ranking of countries with the highest innovation Index (The Global Innovation Index), 2020-2022 is shown in (Table 1).

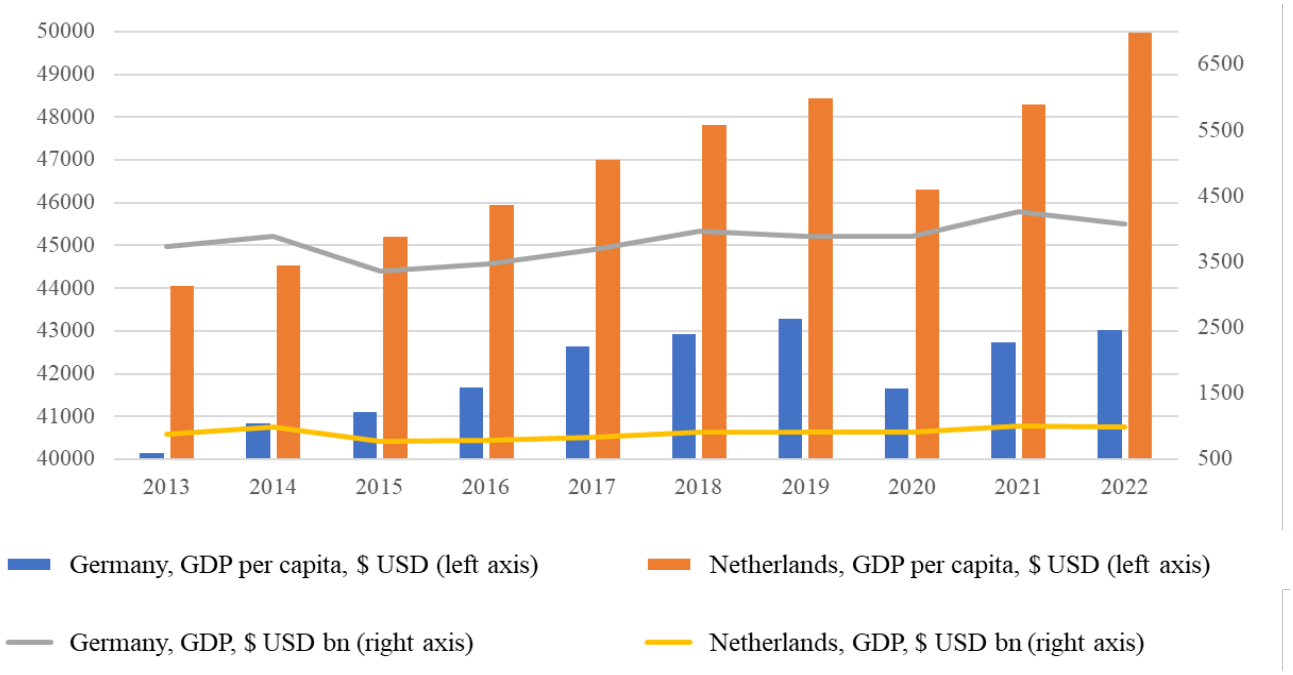


Figure 5. Dynamics of GDP and GDP per capita in Germany and the Netherlands, 2013-2022
Source: composed by authors according to: Trading Economics. https://tradingeconomics.com/ (accessed 01.05.2023).

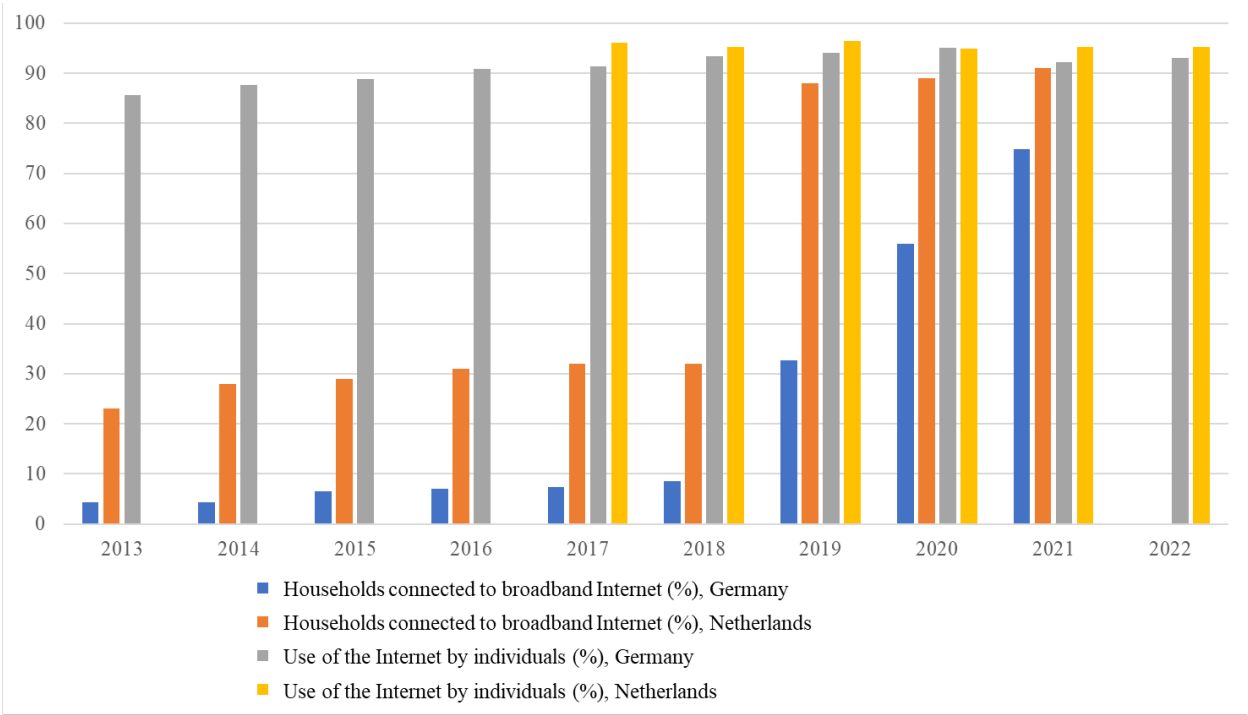


Figure 6. Some indicators of Internet development among individuals in Germany and the Netherlands in 2013-2022
Source: composed by authors according to: Eurostat. High-speed internet coverage. https://ec.europa.eu/eurostat/databrowser/view/SDG_17_60__custom_2400872/bookmark/table?lang=en&bookmarkId=0dbcd702-eabf-4c51-88a1-e10c9f2089e6; Internet use by individuals. https://ec.europa.eu/eurostat/databrowser/view/tin00028/default/table?lang=en; High-speed internet coverage. https://ec.europa.eu/eurostat/databrowser/view/SDG_17_60__custom_2400872/bookmark/table?lang=en&bookmarkId=0dbcd702-eabf-4c51-88a1-e10c9f2089e6; Internet use by individuals/ https://ec.europa.eu/eurostat/databrowser/view/tin00028/default/table?lang=en. (accessed 05.04.2023).

Table 1 – Top 10 countries leading in the ranking of the Global Innovation Index, 2020-2022

Country	2022		2021		2020	
	Index	General location / Location in the region	Index	General location / Location in the region	Index	General location / Location in the region
Switzerland	64.6	1 / 1	65.5	1 / 1	66.08	1 / 1
The USA	61.8	2 / 1	61.3	3 / 1	60.5	3 / 1
Sweden	61.6	3 / 2	63.1	2 / 2	62.47	2 / 2
United Kingdom	59.7	4 / 3	59.8	4 / 3	59.78	4 / 3
the Netherlands	58.0	5 / 4	58.6	6 / 4	58.76	5 / 4
Republic of Korea	57.8	6 / 1	59.3	5 / 1	56.11	10 / 2
Singapore	57.3	7 / 2	57.8	8 / 2	56.61	8 / 1
Germany	57.2	8 / 5	57.3	10 / 7	56.55	9 / 7
Finland	56.9	9 / 6	58.4	7 / 5	57.02	7 / 6
Denmark	55.9	10 / 7	57.3	9 / 6	57.53	6 / 5

Source: Composed by authors according to: Soumitra et al., 2020; Dutta et al., 2021; Dutta et al., 2022

SO.N3, ST.G3. Tax incentives are the strengths of Germany and the Netherlands. However, support for the innovations development, including for the deployment of the 5G network, is provided by the government. At the same time, in Germany, the main form of support was grants for R&D and a tax credit as a reduction in the amount of tax. In the Netherlands, the whole range of support is being implemented, including «superbug», accelerated depreciation, patent «boxes», benefits for salary payments, etc. (Solutseva et al., 2023). In 2020, in order to support enterprises during the COVID-19 pandemic, additional measures were introduced in Germany – grants and subsidies, administrative measures, benefits for small and medium-sized businesses, and assistance to individual industries. In the Netherlands, benefits related to human resources, tax deductions, preferential loans and other financial assistance are actively used (Solutseva et al., 2023).

SO.G2, SO.N4. There is a high demand for fast, high-quality Internet services in the countries. Probably, it could be another incentive for mobile operators to invest in 5G.

SO.G3. The transition to 5G in Germany is also supported by mobile operators. For instance, operators began to close outdated networks from 2021. O2 Company discontinued its 3G network in Germany at the end of 2021, delete frequencies segment of 2100 MHz, which will be used for 4G. In March 2022, Vodafone Germany, the largest German mobile operator, announced its plans on providing nationwide autonomous (SA) network coverage by 2025. When this service distributes across the country, the '5G+' brand will be used (GSMA Association, 2021). 5G SA has additional functionality, which is a key factor in using the advanced capabilities of this technology.

SW.G1. The dependence of German policy on the general guidelines of the European Union cannot be considered only a weak side, as this may bring additional opportunities in the future. The agenda and goals for the development of next-generation mobile networks set by the European Commission may encourage German private and public companies to invest more in 5G to support the regional goals. In 2021, the European Commission got a goal to provide gigabit connectivity in all EU households and 5G coverage in all settlements by 2030 (Eurostat, 2021).

Results: multiplicative effect of the 5G technologies influence on economic development

In order to determine the impact of the introduction of 5G technologies for economic development we use the «input-output» method presented earlier. Investments in 5G technologies are directed for the development of the appropriate infrastructure. In the European Union, these are radio and television equipment, communications (45%), construction (34%), and telecommunications (21%). Investments in

various sectors have an uneven impact on the economy. Therefore there is a need to assess the multiplicative effects of production and employment of types I and II[4].

Table 2 shows this effect in general and on the employed for the countries of the European Union, including the UK. As a result of investments in the 5G technologies development, direct input-output effects of the first type arise. As expected, the production growth will amount to €141.8 bn, which provides the occuring of 2.39 mln vacancies in the EU countries.

Table 2 – Investments in 5G and the resulting effects of the first type, mln euros

Country	Investing in 5G in 2020	Direct input-output effect of the first type	Direct input-output effect for the employed of the first type
Germany	9,280	20,740	211,100
United Kingdom*	7,040	16,520	172,100
France	7,030	17,110	224,700
Italy	6,830	15,700	186,830
Spain	5,190	14,600	329,400
the Netherlands	1,870	5,030	68,300
Poland	4,350	13,040	569,553
Belgium	1,230	3,150	36,300
Sweden	1,060	2,450	25,300
Austria	970	2,170	25200
Ireland	490	1,210	10,700
Denmark	620	1,480	14,800
Finland	600	1,501	19,900
Romania	2,270	4,660	252,300
Czech Republic	1,200	3,990	143,000
Portugal	1,170	3,730	127300
Greece	1,220	2,180	101,300
Hungary	1,130	3,450	134,600
Slovakia	620	1,980	71,500
Bulgaria	840	2,320	128,900
Luxembourg	60	122	600
Croatia	480	2,320	64,400
Lithuania	330	700	28,200
Slovenia	240	610	14,700
Latvia	230	570	16,800
Estonia	150	560	13,600
Cyprus	100	470	20,800
Malta	50	190	3,900

Source: European Commission. Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe. – Tech. Rep. 30-CE-0683419/00-45, 2016. https://connectcentre.ie/wp-content/uploads/2016/10/EC-Study_5G-in-Europe.pdf (accessed 13.03.2023).

[4] *European Commission. Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe. – Tech. Rep. 30-CE-0683419/00-45, 2016. https://connectcentre.ie/wp-content/uploads/2016/10/EC-Study_5G-in-Europe.pdf (accessed 13.03.2023).*

The matrix of direct effects from the 5G technologies implementation in the EU countries is shown in Figure 7. Horizontally, we note a direct effect for the employed or the number of vacancies, and vertically – GDP growth, or, a direct economic effect.

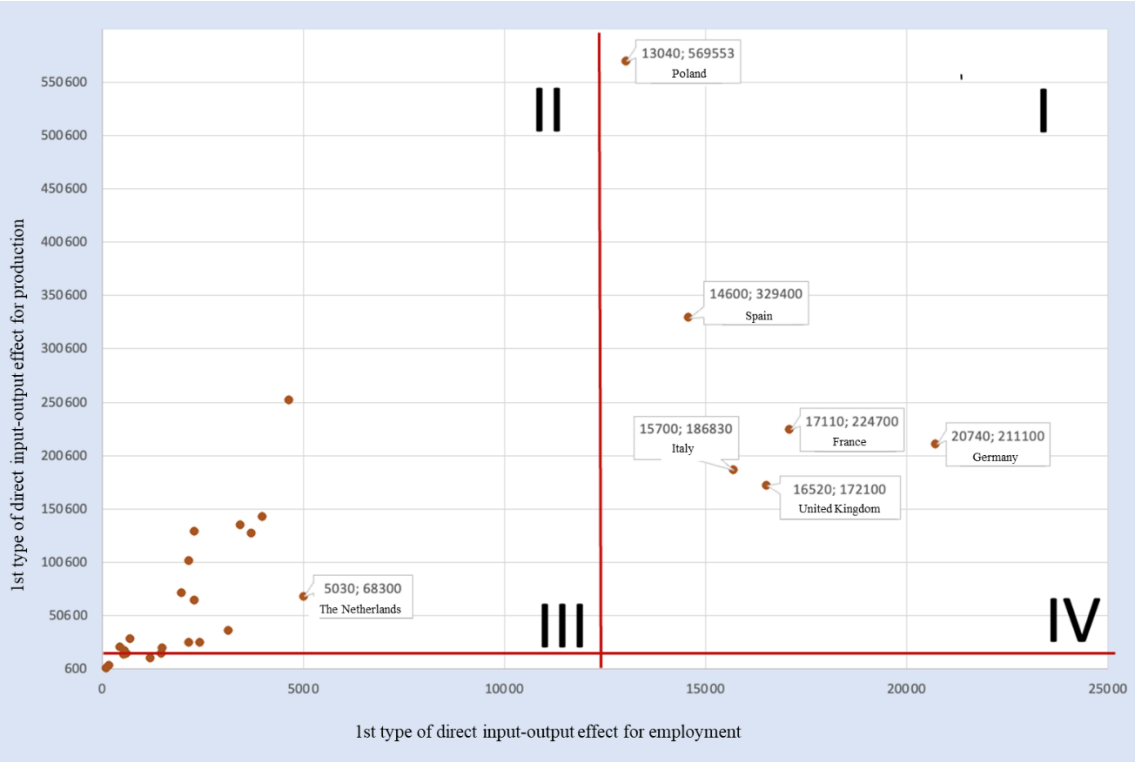


Figure 7. Matrix of economic effects on production and employment from the 5G implementation
Source: composed according to the European Commission. Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe. https://op.europa.eu/en/publication-detail/-/publication/2baf523f-edcc-11e6-ad7c-01aa75ed71a1/language-en (accessed 07.05.2023).

According to our research, the countries can be divided into four groups. For example, Poland, Spain, Italy, France, Germany, and the UK have the greatest effects in both directions. A number of countries benefit from the implementation it for production, including the Netherlands. A small group of countries have lower than average effect in the EU. However, there are no countries that would benefit more only for the employed – the economic effect is always presented.

Now, the 5G technologies implementation is not the only factor of economic development. Therefore, we propose to separate it from others by removing the scale factor of the economy, correlate the indicators to the largest country, and normalizing them. Rationing will allow us to compare the effects of the 5G technologies implementation on the production volume and the number of vacancies, if the scale of the economy and employment in all countries were comparable to the most effective regional economy – German one.

For the investment indicator, we calculate the rationing coefficients. They show the ratio of the most effective economy GDP to the GDP of the selected country economy.

Germany is the economy with the largest GDP in the EU. The country's GDP is € 3,889,669 mln. We calculate the rationing coefficient for investments in 5G in France:

$$qf_I = \frac{GDP_{GER}}{GDP_{FRA}}, \quad (4)$$

where:
GDP_{GER} – German GDP in 2020;
GDP_{FRA} – French GDP in 2020;
qf_I – the rationing coefficient for investments.

$$qf_I = (3\ 889\ 669)/(2\ 639\ 009) \approx 1{,}47 \quad (5)$$

Hence, German economy is 1.47 times more effective than the French one. Therefore, it is necessary to normalize investments in 5G by the same amount for compare them:

$$invest_{5G_{adj}} = qf_I * invest_{5G}, \quad (6)$$

where:
$invest_{5G_{adj}}$ – normalized investment volume;
qf_I – rationing coefficient for investments;
$invest_{5G}$ – the volume of investments.

$$invest_{5G_{adj}} = 1{,}47 * 7030 = 10\,362 \quad (7)$$

Similarly, we calculate the rationing coefficient for input-output production effects. For labour force indicators, we calculate rationing coefficients, which indicate the ratio of the size of the labour force in the country where it is largest to the size of the labour force in the selected country.

The country with the largest size of the labour forces is Germany – 43,501,000 employees in 2020. For example, we calculate the rationing coefficient for the first type of input-output effect for employment in France:

$$\boldsymbol{qf_{\mathrm{E}} = \frac{Labor\_force_{GER}}{Labor\_force_{FRA}}}, \quad (8)$$

where:
qf_E – rationing coefficient;
$Labor\_force_{GER}$ – labour force in Germany in 2020;
$Labor\_force_{FRA}$ – labour force in France in 2020.

$$qf_{\mathrm{E}} = (43\,501\,000)/(30\,379\,000) \approx 1{,}43 \quad (9)$$

Therefore, we can conclude that German labour force is 1.43 times larger than the French one, so it is necessary to normalise the 5G effect on employment (job gains) by the same value:

$$\boldsymbol{type\ I_{effect_{E_{adj}}} = qf_E * type\ I_{effect_E}}, \quad (10)$$

where:
type $I_{effect_{E_{adj}}}$ – the effect of the 5G implementation for employment is normalized;
qf_E – rationing coefficient;
type $I_{effect_{\mathrm{E}}}$ – the effect of the 5G implementation for employment.

$$\boldsymbol{type\ I_{effect_{E_{adj}}} = 1{,}43 * 224\,700 = 321\,175} \quad (11)$$

After the normalisation procedure, it is possible to use bar charts to demonstrate the countries for which the effect of 5G implementation on selected indicators will be the highest.

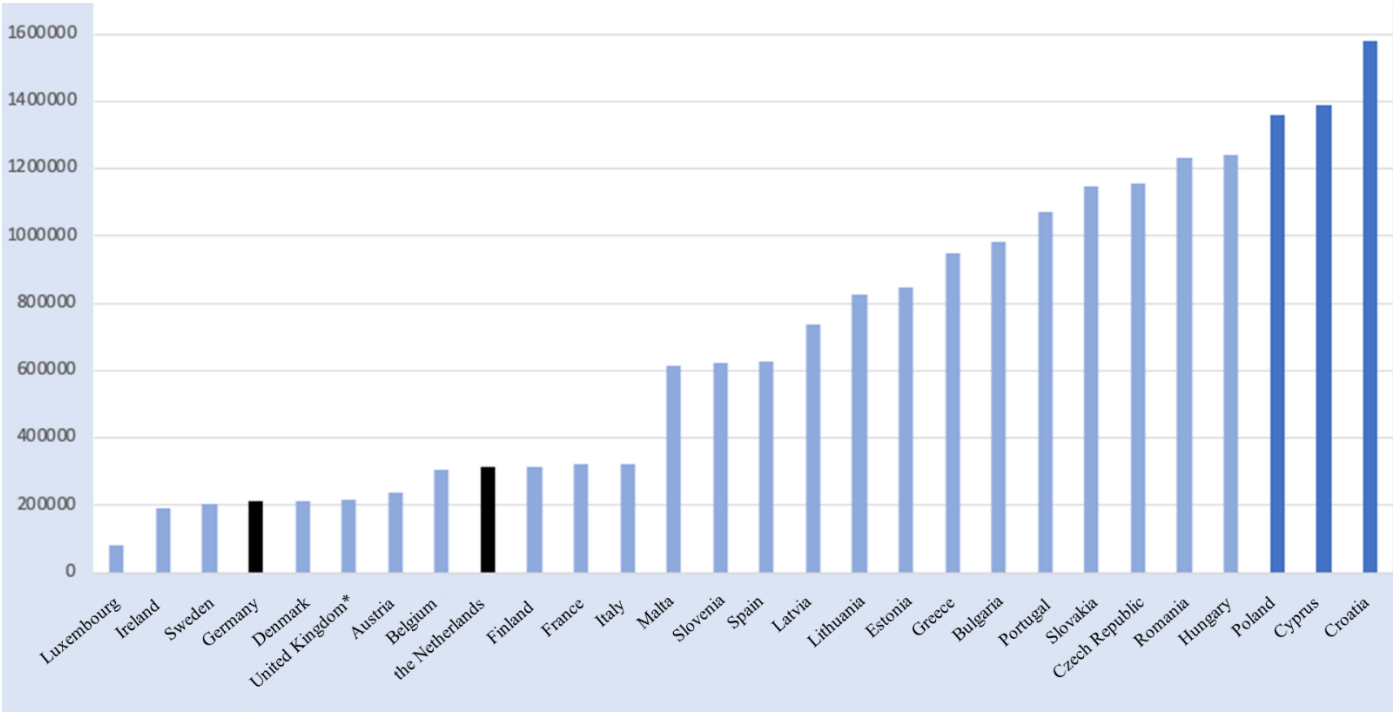
Firstly, consider the effect 5G investments in manufacturing (Figure 8). Here the largest effect of 5G investments will be in smaller countries (Croatia, Bulgaria, and Hungary). In terms of employment opportunities, countries such as Croatia, Cyprus, and Poland will benefit considerably.

To verify the representativeness of the obtained results, we will calculate the multiplier effect for each country from investments in 5G. The multipliers will allow us to assess the relationship between the increase in investment and the change in production and employment (Table 3).

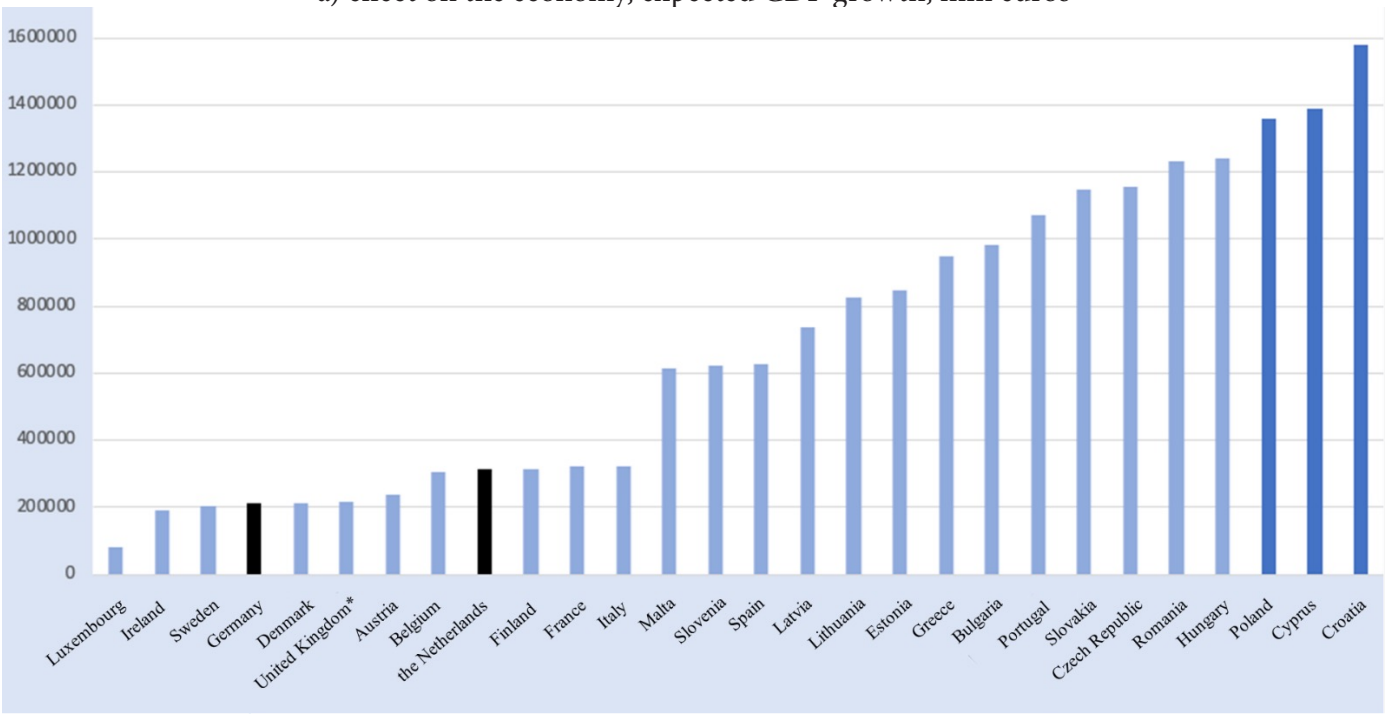
Consequently, the multiplicative effect of 5G investments is higher for lower economies. The countries with the highest multiplier for production (value equal to 4 and 5) are Cyprus, Croatia, Estonia, and Malta. Therefore, the increase in national output is expected for every million euros of investment by 4 and 5 million euros, respectively. The highest multiplier for employment is possessed by countries such as Cyprus, Bulgaria, Croatia, Poland, Hungary, with values of 208, 153, 134 and 131 respectively. An increase in employment for every million euros of investment in 5G will be accounted for by the multiplier value for the country concerned. These data are correlated with the results obtained after the rationing procedure.

For effective economies, the multiplier effect of the 5G technologies implementation will lower, but in

absolute terms it is quite high.



a) effect on the economy, expected GDP growth, mln euros



b) effect for the employed, expected new vacancies, people

Figure 8. Effects on economic development and employment growth from the 5G technologies implementation in the UN countries

Source: composed by authors

Table 3 – Multiplier effects for production and employment from the 5G technologies implementation in the UN countries

Country	The multiplier effect for production	The multiplier effect for employment
Croatia	5	134
Cyprus	5	208

Country	The multiplier effect for production	The multiplier effect for employment
Malta	4	78
Estonia	4	91
Czech Republic	3	119
Slovakia	3	115
Portugal	3	109
Hungary	3	119
Poland	3	131
Spain	3	63
Bulgaria	3	153
the Netherlands	3	37
Belgium	3	30
Slovenia	3	61
Finland	3	33
Latvia	2	73
Ireland	2	22
France	2	32
Denmark	2	24
United Kingdom*	2	24
Sweden	2	24
Italy	2	27
Austria	2	26
Germany	2	23
Lithuania	2	85
Romania	2	111
Luxembourg	2	10
Greece	2	83

Source: composed by authors

Consequently, the multiplicative effect of 5G investments is higher for lower economies. The countries with the highest multiplier for production (value equal to 4 and 5) are Cyprus, Croatia, Estonia, and Malta. Therefore, the increase in national output is expected for every million euros of investment by 4 and 5 million euros, respectively. The highest multiplier for employment is possessed by countries such as Cyprus, Bulgaria, Croatia, Poland, Hungary, with values of 208, 153, 134 and 131 respectively. An increase in employment for every million euros of investment in 5G will be accounted for by the multiplier value for the country concerned. These data are correlated with the results obtained after the rationing procedure.

For effective economies, the multiplier effect of the 5G technologies implementation will lower, but in absolute terms it is quite high.

Conclusions

The 5G technologies implementation at the national level enhances the investment attractiveness of the territory. It allows companies to increase income through better customer service, superiority over competitors, increased demand, reliability, production and reduced risks and costs.

In many ways, the development of 5G technology depends on the interest and policy of the government. In Germany, the goal of maximizing the potential of the technology was set back in 2017. Germany is planned to become the leading market for 5G implementation. The «5G-Strategie für Deutschland» strategy,

adopted in the same year, consolidated and regulated all measures taken with regard to the implementation and development of 5G mobile technologies. It extends to 2025 and includes five strands: accelerating network deployment; providing the most optimal frequencies for 5G; promoting co-operation between telecommunications companies and users; supporting 5G research and its deployment in cities at an early stage (BMDV, 2021).

R&D and technology development remains dynamic. Today, while discussing the prospects and challenges of implementing 5G technologies, we can reasonably assume and predict the introduction of the next generation of technologies – 6G. Since every innovation brings significant benefits but also has a shorter lifespan, the occurrence of 6G is not remote. These technologies are expected to be implemented in the development of smart cities, namely digital twins, augmented reality, the Internet of Things, etc. (Allam & Jones, 2021).

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' CONTRIBUTION

Svetlana N. Rastvortseva – concept, project administration, reviewing and editing.
Irina A. Bondarenko – formal analysis, collecting data, project design.

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