The role of information and communication technologies in regional development

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Technological progress is a key factor in the economic development of countries. The competitiveness of a nation in the long term relies on the innovative potential of its economy, which can be ensured through the transfer of knowledge, an important part of which is ICT - information and communication technology.

ICTs contribute to economic growth and the achievement of the 2015 Sustainable Development Goals (Sharafat and Lehr, 2017, p. i). ICTs are changing the creation, production, distribution, and sale of all goods and services, improving the quality of products (Farhadi et al., 2012), not just digital or information products (Sharafat and Lehr, 2017, p. iii). They fundamentally change the nature of global relationships, create new sources of competitive advantage for companies, industries, and countries, increase productivity, and create new conditions for social and economic development. ICT development reduces the cost of creating new innovative small businesses (Can and Terziev, 2016).

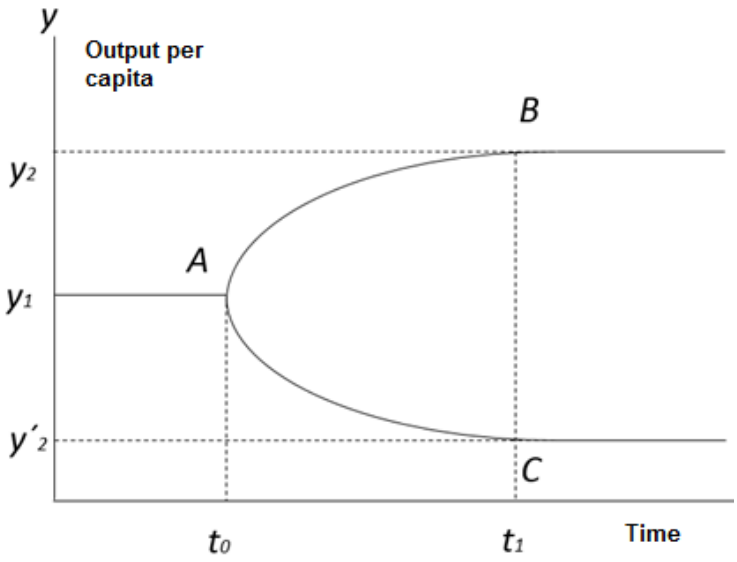
ICTs are responsible for how people, consumers, industrial companies, and governments produce (acquire) and disseminate knowledge around the world (Sharafat and Lehr, 2017, p. iii). Information and communication technologies are becoming an integral part of national and regional innovation systems, and ICT directions are included in the strategies of many countries around the world.

It has been empirically proven that information and communication technologies make a major contribution to economic growth and can be a consequence of it. ICT infrastructure is one of the four bases of the concept of knowledge economy. Information and communication technologies are an important component of innovation. ICTs are tools for "unleashing creativity and knowledge embodied in people" (World Bank, 2018). In other words, ICTs enable the creation of tacit knowledge and transform it into explicit knowledge, which facilitates better replication and diffusion of innovation and technology. Through technology transfer, the competitiveness of a nation can be ensured in the long term, and the intensity of technology transfer depends on the innovation capacity of the host country. Thus, we can substantiate the indirect impact of ICT development on the socio-economic situation and growth of the national and regional economy.

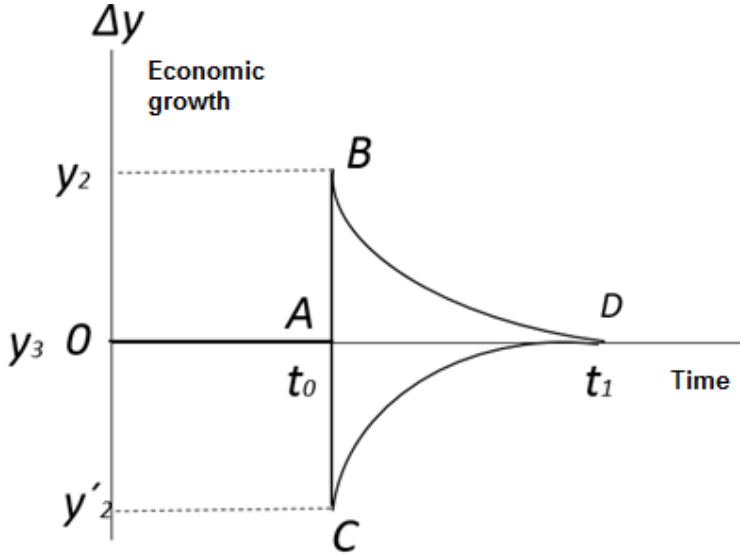
ICTs are among the universal technologies, because they create the opportunity for ubiquitous use in different ways, are the basis for the emergence of subsequent innovations, become a factor in changing the quantitative and qualitative indicators of resource allocation and output. But there are also opinions that the effect of ICT is insignificant and stretched over time.

We propose to use static and dynamic approaches to assess the impact of ICT factors on socio-economic indicators of development of regions and countries. The static approach is based on the use of the Cobb-Douglas production function, which after some transformation shows that output per capita depends on capital per capita and total factor productivity. Total factor productivity in our study is represented by indicators of ICT infrastructure development. Similarly, using the neoclassical growth model, we conclude that per capita output growth is equal to per capita capital growth and total factor productivity growth or technological progress (dynamic approach).

The application of static and dynamic approaches involves estimating the effect of a certain list of explanatory variables on both the level of output and economic growth. We expect this effect to be different and would like to explain it (fig. 1 (a) and (b)).



(a) Impact on the level of production per capita (Stage 1)



(b) The relevant impact on economic growth (Stage 2)

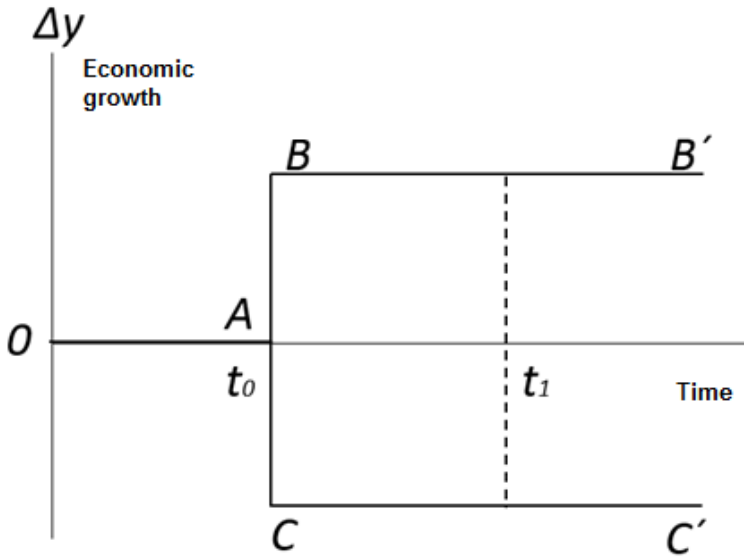
Compiled by the author according to (Dornbusch, 2011; Yusuf, 2021).

Fig.1. Effect of changes in explanatory variables on (a) per capita output and then on (b) economic growth

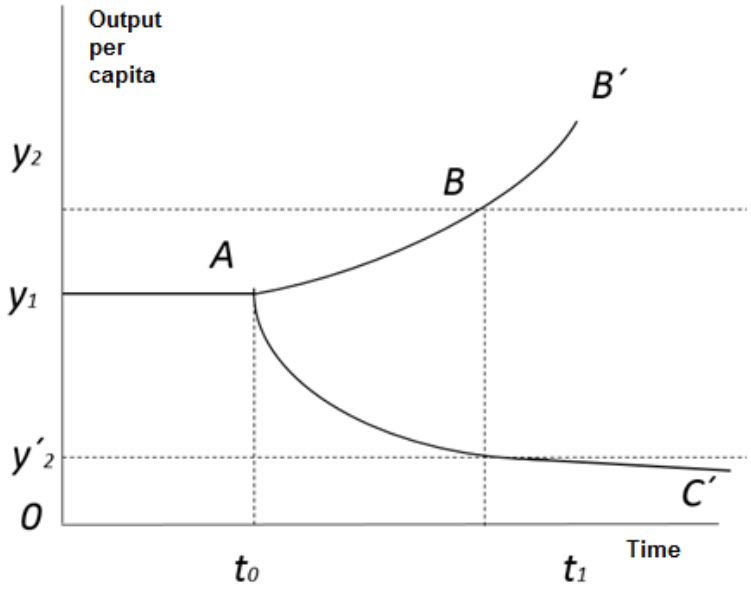
In Fig. 1 (a) we see that an increase in the explanatory variables leads to a one-time increase in production per capita - the indicator moves from point A to a higher value - point B. If there is a decrease in the explanatory variable, then the AC trajectory is fulfilled - production per capita decreases one time. Let us note that in both the first and second cases the position B or C achieved is preserved in the future.

The corresponding effects on economic growth are shown in (b). An increase in the explanatory variable leads to a one-time increase in output per capita, while a decrease leads to a decrease, respectively. But when the effect is aimed at increasing the level of output per capita (not economic growth), this effect is short-lived, and in the long run the level of economic growth returns to the initial position.

Consider another situation in which efforts are aimed directly at increasing economic growth rather than output per capita (fig.2 (a) and (b)).



(a) Impact on economic growth (Stage 1)



(b) The corresponding effect on the level of production per capita (Stage 2)

Compiled by the author according to (Yusuf, 2021).

Fig 2. Effect of changes in explanatory variables on (a) economic growth and then on (b) per capita output

If there is an effect on economic growth, a change in the explanatory variable will cause the rate of economic growth to rise or fall, and it will remain at the same level over time. A sustained growth rate at a higher point (above zero) will result in a constant and exponential increase in output. A decrease in the rate of economic growth will lead to a monotonic decrease in output, but not to zero.

Thus, the influence of the selected factors on the level of production per capita has a one-time nature and is reflected in the rate of economic growth only in the short term. The impact of the factors directly on the rate of economic growth has long-term tendencies and stimulates an exponential increase (decrease) in the level of production per capita.

Two equations based on panel data are constructed to assess the influence of factors on the overall factor productivity (1) and its growth (2):

$$lnA = \beta_1 + \beta_2 lnICT + \beta_3 lnGOV + \beta_4 lnEXP + \beta_5 lnINFL + \varepsilon \quad (1)$$

$$\frac{\Delta A}{A} = \beta_1 + \beta_2 lnICT + \beta_3 lnGOV + \beta_4 lnEXP + \beta_5 INFL + \varepsilon \quad (2)$$

where ICT as FTS – fixed telephone subscriptions per 100 inhabitants; MCS – mobile cellular subscription per 100 inhabitants; FBS – fixed broadband subscription per 100 inhabitants; IU – internet users as percentage of population; INV – gross fixed capital formation as a ratio of GDP; $\frac{\Delta A}{A}$ – economic growth; Y – real income per capita; INFL – inflation rate; GOV – general government final consumption expenditure ratio; EXP – Export of goods and services ratio (to GDP); A - real income per capita; $\frac{\Delta A}{A}$ - economic growth.

We apply static and dynamic approaches to analyze the impact of ICT on economic development and growth in the European Union. The first calculations for the period 2000-2020 showed either a negative ICT impact on economic development, or a statistically insignificant one. However, similar studies on countries and regions of Africa (Yusuf, 2021) and the author's study of Russian regions for the same period showed a significant positive impact. This allows us to assume that the components of information and communication technology have played a role in economic development in the European Union in an earlier period or with a lag.

Following this assumption, we expanded the analyzed period - from 1960 (namely, 1960, 1965, 1975-2020). For a number of indicators we used data from the moment they were reported in statistics. A series of models of the impact of ICT components on economic development (tabl.1) and economic growth (tabl.2) in 27 countries of the European Union for the period 1960-2020 were constructed, but not before the advent of technology.

Table 1 - Regression results, economic development, countries EU, 1960-2020

Variables	ln_FTS	ln_MCS	ln_FBS	ln_IU
Time	1960-2020	1980-2020	1998-2020	1990-2020
const	4,145*** (0,908)	6,694*** (1,073)	4,510*** (0,659)	6,509*** (1,097)

ICT	0,763*** (0,148)	0,075*** (0,018)	0,19*** (0,03)	0,063* (0,035)
ln_GovExp	0,683** (0,286)	0,762*** (0,268)	1,317*** (0,193)	0,808*** (0,289)
ln_EXP	0,305*** (0,088)	0,249*** (0,082)	0,326*** (0,045)	0,284*** (0,065)
ln_infl	-0,024*** (0,038)	-0,322*** (0,055)	-0,127** (0,047)	-0,33** (0,062)
Number of observations	1002	803	496	721
R^2	0,455	0,295	0,287	0,282
Standard model error	0,811	0,844	0,769	0,879

Source: Author's computation, 2022. Explanatory Note: ***, ** and * indicate significance at the 1%, 5% and 10% level. Variable *ln_INV* in all four models is not statistically significant, so it was removed from the table.

The constructed static models showed the following results:

1) the development of fixed telephony had a positive and significant impact on GDP per capita between 1960 and 2020;

2) the positive impact of mobile telephony was more pronounced in the period since 1980;

3) the number of fixed broadband subscribers had a positive impact on economic development since 1998;

4) the share of Internet users in the total population had a positive effect on the economy in the period since 1990;

5) cumulatively, the impact of ICT indicators on GDP per capita occurred from different starting periods, but persisted until 2020;

6) government spending, like exports, had a positive impact on economic development in the short term;

7) inflation, which is expected to be negative for economic development;

8) the impact of gross fixed capital formation in all static models is insignificant.

Table 2 - Regression results, economic growth, countries EU, 1960-2020

Variables	ln_FTS	ln_MCS	ln_FBS	ln_IU
Time	1975-2020	1980-2001	1998-2020	1991-2006
const		2,000* (1,004)		
ICT	lag (3) 0,182** (0,066)	lag (1) 0,062* (0,036)	lag (5) 0,113*** (0,035) lag (6) -0,139*** (0,032)	lag (3) 0,060* (0,035)

ln_INV	0,933*** (0,167)	0,442* (0,223)	1,359*** (0,233)	0,872*** (0,284)
ln_GovExp	-1,209*** (0,177)	-1,179*** (0,334)	-1,455*** (0,220)	-0,978*** (0,3)
ln_EXP	0,273*** (0,057)	0,313*** (0,065)	0,27*** (0,083)	0,316*** (0,066)
Number of observations	803	267	319	285
R^2	0,623	0,149	0,649	0,693
Standard model error	0,830	0,741	0,745	0,792

Source: Author's computation, 2022. Explanatory Note: ***, ** and * indicate significance at the 1%, 5% and 10% level. Variable *ln_infl* in all four models is not statistically significant, so it was removed from the table.

The impact of the development of the main elements of ICT on economic growth has been determined in a less direct way:

1) the fixed telephone network has a positive effect on economic growth since 1975 (not since 1960, as in the impact on economic development) and with a lag of 3 years;

2) mobile telephony has a positive effect on economic growth with a lag of 1 year and in the 1980-2001 period (in the static analysis, the period to 2020);

3) the positive impact of fixed broadband can be traced to 1998 (as in the static analysis), but with a lag of 5 years;

4) the share of Internet users in the total population has a positive and statistically significant impact on economic growth between 1991 and 2006, with a lag of 3 years;

5) gross fixed capital formation has a significant and positive impact on economic growth;

6) exports have a positive impact in both groups of models;

7) in dynamic models, government spending has a negative impact on economic growth, indicating that it is an instrument of short-term impact on the economy;

8) the inflation indicator was excluded from the models due to statistical insignificance.

Thus, we see that the development of ICT infrastructure is a necessary but not sufficient measure for the innovative development of the economy. It gives the best results at the stage of formation - in the European Union earlier, before 2000, in the Russian regions, as in Africa - later. Later, the role of information and communication technologies in the development of innovation and the economy moves from stimulating to supporting innovation.

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