HSE UNIVERSITY

Human Capital
Multidisciplinary
Research Center

General Purpose Technologies, Human Capital and Economic Growth

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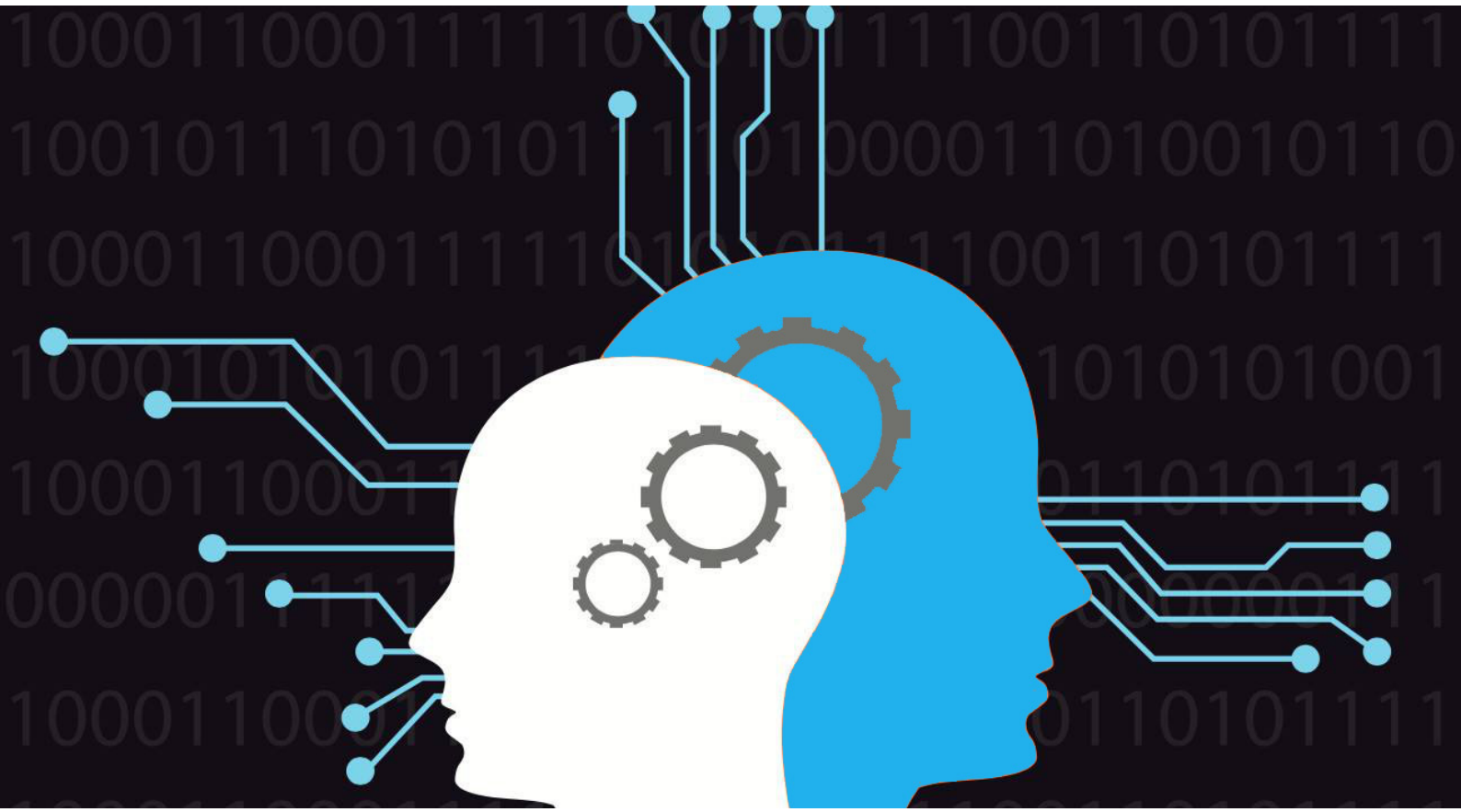


The world-class Human Capital Multidisciplinary Research Center was established in November 2020 under the National Project “Science” as a consortium of four leading institutions in this field of science: NRU HSE, RANEPA, MGIMO MFA of Russia and Russian Academy of Sciences N.N. Mikloukho-Maklay Institute of Ethnology and Anthropology.

The creation of the Center has become Russia’s most ambitious undertaking in the field of social sciences and humanities in recent decades. The Center’s key tasks include not only performing world-class research, but also establishing cooperation with leading international organizations, launching educational programs, setting up state-of-the-art research infrastructure, transfer of the knowledge gained into governance and education.

The Center implements 80 research projects. The research program covers key aspects of human capital that feature prominently in the global agenda:

Social Sciences and Humanities Aspects of Human Capital

Neurocognitive Mechanisms of Social Behavior

Demography and Active Ageing

Natural and Climatic Factors Affecting Sustainable Development

Employment, Social Activity and Development of Key Skills and Competences

Human Capital and Security in the Global Context

Human in the Era of Technological Transformations

This digest was produced under the research project Economic Growth, Human Capital and General Purpose Technologies in the Context of Global Slowdown

Human Capital Multidisciplinary Research Center Research Digest Project supervised by Olga Voron.
Written by Ilya Voskoboinikov.
Edited by Anastasia Andrianova. Translated by Andrei Salnikov.

Introduction

Balanced long-term economic growth is based on the improvement of technology and the special role of human capital. Different technologies play different roles. Special-purpose technologies allow to improve the production of a specific product (for example, a textile machine). They penetrate almost all areas of production, change the structure of the economy and relationships in society (the Internet). What are general purpose technologies today? What is their role? Does the interaction of such technologies with human capital lead to faster or slower growth? All these questions apply to any country and any economy. But how can we isolate the impact of these general factors from the specific features of the development and growth of the Russian economy?

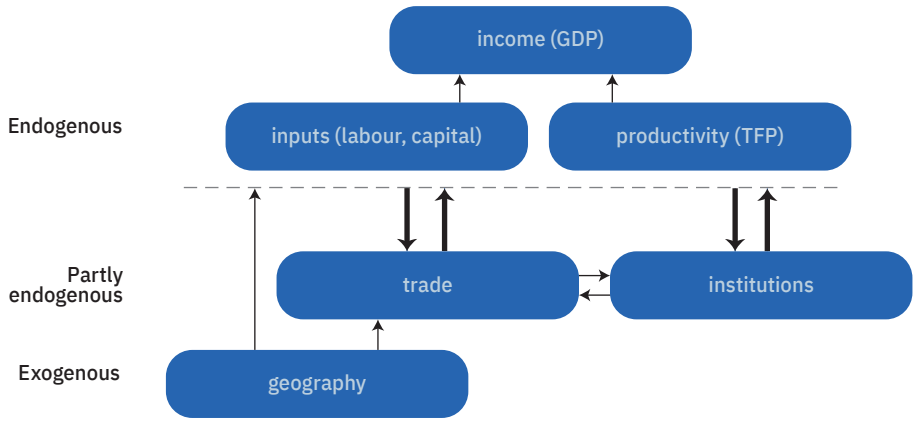
To answer these questions, we need to accurately measure growth factors; take into account sectoral specificities of growth; use alternative conceptions of human capital and refine definitions of general-purpose technologies; consider economic development and growth processes over a longtime horizon of decades; and make intensive use of cross-country comparisons of output, factors of production, and productivity at the level of the economy as a whole and individual industries.

How Long-Term Economic Growth Works?

To what extent is global economic growth shaped by the inputs made by human capital and technological development? What are the mechanisms of interaction? What is the role of these global growth factors in the development of the Russian economy?

The nature of economic growth has been studied by economists for decades. In fact, all modern knowledge about economic growth can be summarized in one diagram shown in Figure 1. The diagram gives a simple and short answer to the question of what generates growth. Direct (endogenous) factors of growth include inputs of labor, physical and human capital, and productivity. Labor input is the total hours worked by all workers in the economy in a year. The physical capital input can also be defined as the time of using buildings, structures, machines, mechanisms, information and computer equipment, as well as software and other intangible assets in production. The human capital input is more difficult to describe in terms of measurable indicators such as hours worked and capital stocks. Human capital inputs are roughly related to the number of hours worked by workers who are more productive thanks to knowledge, skills, physical strength and other personal characteristics. Finally, economic growth through productivity is associated with a reduction in the costs of the above factors of production per unit of output. In other words, if productivity increases, a unit of output requires fewer hours of work and less physical and human capital to produce it.

Figure 1
How long-term economic growth works?



Source: (Rodrik 2003).

In addition to the direct factors of production, there are primary factors of production. They shape labor, capital and productivity. Primary factors can be organized into three large groups, shown in Figure 1 – geography, institutions and trade. For example, the number of hours worked (labor) is related to the total size of the labor force. In its turn, it is shaped by the dynamics of fertility and mortality – a consequence of a complex interaction of other primary factors – family and cultural traditions, the state of the health care system, the state and dynamics of the labor market (institutions). Capital is related to the state of the stock market, the appeal of the economy to foreign direct investment and its openness (trade), as well as its natural resources (geography).

Some primary factors affect several direct factors of production simultaneously. For example, foreign direct investments (geography and institutions) increase physical capital and contribute to productivity growth through the inflow of new technologies and new work relations. In this sense, the mechanism of fixed capital accumulation through FDI inflows is different from the mechanism of new technologies adaptation and the corresponding productivity growth. Thus, it is important to separate the economic mechanisms that link primary sources of growth and specific factors of production.

It is possible to study individual mechanisms of economic growth (causal relationships between primary factors and growth factors) if we can measure the level and dynamics of labor, capital and productivity. The more accurate this measurement is, the higher the probability to see the manifestations of these mechanisms in the data.

Technology plays a special role in this overall picture. In principle, adapting new technologies can lead to lower production costs and higher productivity, – nothing new here.

Some time ago, economists noticed that technologies differ in their impact on production and society. A new technology can increase productivity in a particular area. For example, using a drill bit made of a stronger material will increase the productivity of a drilling machine. At the same time, a new technology can increase productivity in many industries and transform an economy in a matter of years or decades. The introduction of the steam engine led to the emergence of large-scale production facilities in cities because the machines could be located freely without being tied to the "traditional" source of energy – the water engine. No less sweeping changes were brought about by the development of electric grids, the advent of personal computers and the Internet. Technologies of the first type are *special-purpose* technologies and those of the second type are general-purpose technologies. The proliferation of *general-purpose* technologies is often global and contributes to productivity growth everywhere. The global economy last experienced such a period of growth with the massive spread of information and communication technologies in the second half of the 1990s and early 2000s.

This project aims to learn how to distinguish between global factors of economic growth related to general-purpose technologies (GPT) and human capital and specific, local factors determined by the peculiarities of the Russian economy and its interaction with the outside world, considering the growth of the Russian economy in a cross-country context. This entails identifying technologies in all sectors and describing the nature of technological development.

The Russian Economy Today and Tomorrow: How to Learn to Distinguish Global Long-term Factors from Short-term Local Shocks?

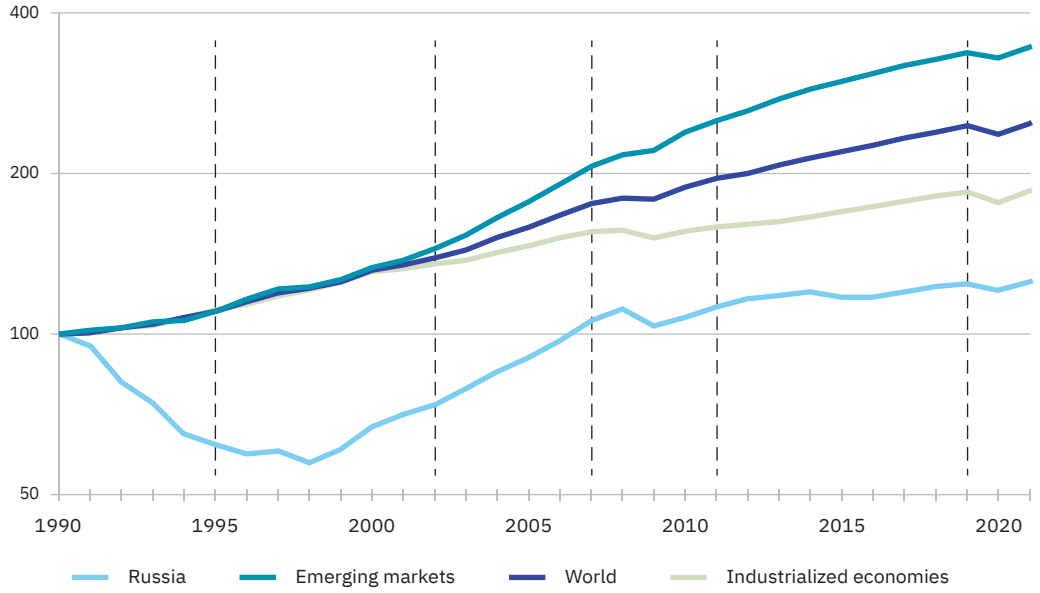
Economic growth in Russia is a consequence of two factors. The first group of factors is global in nature, including the effect of GPT. For example, today it is the spread of the Internet. The second group of factors is related to the peculiarities of a particular country – its geographical location, industry structure, institutions, involvement in global trade, external and internal shocks.

The dynamics of Russia's economic growth compared to other countries over the last three decades against the background of the world economy growth (Fig. 1) demonstrates clearly how Russia's growth trajectory got closer to the global trajectory as Russia developed into a market economy and became integrated into the world economy. While the transformational recession against the background of stable growth in the world (1990-1998) is a Russian phenomenon, the rapid growth in 2002-2007 is already part of the global trend. It reflected both Russian and global features. The former include recovery from recession, inflow of investments due to the growth of revenues from sales of energy, and technological catch-up. The latter include a revolution in the penetration of information and communication technologies into all spheres of life. While the 1998 crisis was a local phenomenon characteristic of Russia and some neighboring countries, the impact of the shocks in 2008 and 2021 Russia experienced together with the entire world[1].

[1] More detail on the role of non-tangible assets and ICT see in (Bobyleva 2022). Russia in the global context is represented in (Timmer and Voskoboynikov 2016; Voskoboynikov 2018).

Figure 2

GDP dynamics in Russia, developed economies and emerging markets in 1990–2021. (1990 = 100)



Sources: The Conference Board Total Economy Database™, August 2021 (World, Industrialized Economies, Emerging Markets); Rosstat (Russia).

Note: World economy indicators are calculated based on data for 122 countries presented in the Total Economy Database ™. The group of fast-growing and emerging markets includes China, India, emerging markets of Asia, Latin America, the Middle East, Africa, Russia, Central Asia and Southeast Europe. Data for Russia

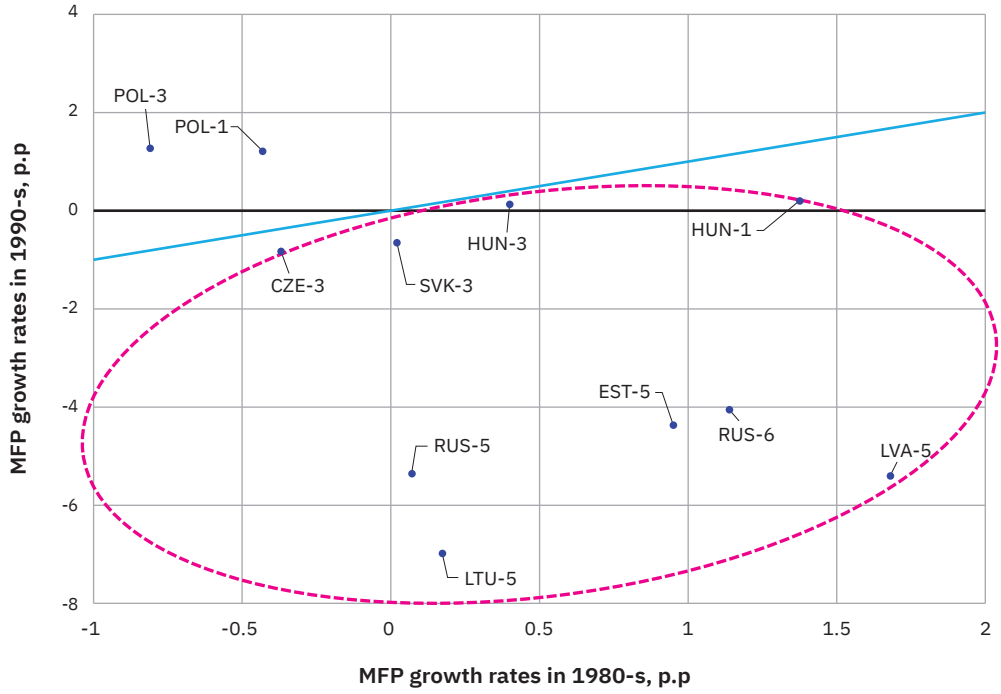
The comparisons presented in Figure 2, as well as the analysis of the structure of economic growth in the cross-country context, require a system of indicators of the Russian economy harmonized with the system of indicators of other countries, as well as identifying factors of production and productivity by a method that would be uniform for different countries. One of the tasks under the project is to perform economic measurement of factors of production and output, as well as to integrate the estimated indicators for the Russian economy.

Why it is Important to Consider the Long Term to Understand Growth?

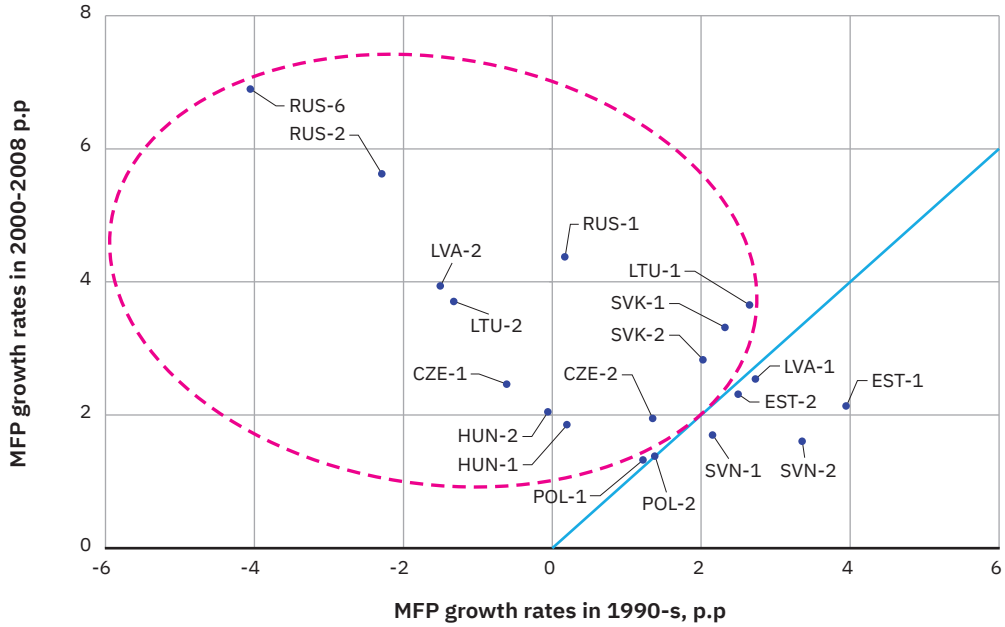
To assess the impact of general-purpose technologies we need to identify a global component responsible for the contribution of technological development to growth and is characteristic of different countries. This component *may* be reflected in the dynamics of multifactor productivity. However, multifactor productivity, with its growth signaling a decline in the cost of production per unit of output, is a tricky indicator to measure. It can be assessed with high accuracy only over large time intervals. And if such an assessment can be made, trends common to a large group of countries become very visible (Figure 3).

Figure 3
Episodes of acceleration and deceleration of Eastern Europe and Russia in 1980–2020
Average annual growth rate (% per annum).

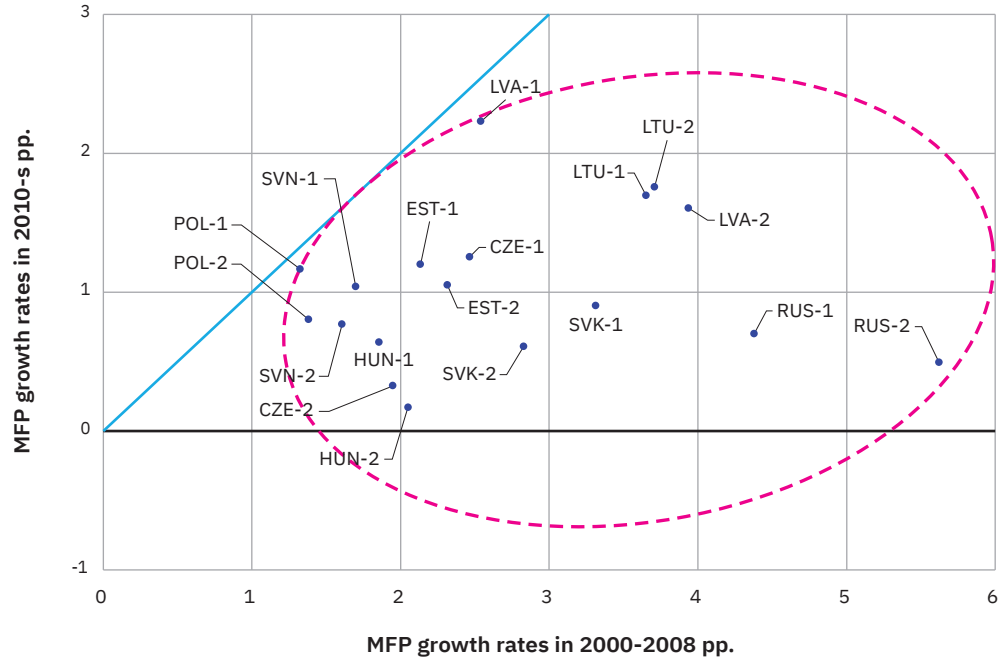
a. The last decade of the planned economy and transition to the market, 1980–1989; 1990–1999



b. Transition and post-transformation recovery.
1990–1999; 2000–2008



c. Post-transformation recovery and stagnation of 2010s.
2000–2008; 2010–2019



Source: (Voskoboynikov 2023).

Country codes: Czech Republic (CZE), Estonia (EST), Hungary (HUN), Latvia (LVA), Lithuania (LTU), Poland (POL), Slovakia (SVK), Slovenia (SVN), Russia (RUS). The number corresponds to MFP estimates obtained in different publications for different years for different countries (see details in Annex A1 (Voskoboynikov 2023).

Figure 3 shows the countries of Eastern Europe and Russia, which experienced similar stages of development in 1980-2020 – stagnation in the planned economy period, transformational recession, recovery growth and global slowdown. Figure 3 reveals whether productivity accelerated or decelerated during the transition between successive development periods. The horizontal axis plots the rate of productivity growth in the earlier period, while the second axis plots the rate of productivity growth in the later period. The blue line is the bisector. If the productivity growth rate of a particular country was accelerating, the point on the diagram would be above the bisector. In contrast, if it was slowing down, it would be lower. For example, in Fig. 3a Russia (RUS-6) showed a moderate growth of multifactor productivity in the 1980s, amounting to 1.1% per year, and in the years of transformational recession – a slowdown of -4.1% per annum. The corresponding point falls below the bisector and indicates a slowdown in productivity. This deceleration, as the figure shows, is common to almost all the Eastern European countries under consideration, with the exception of Poland. The widespread decline in productivity in the first years after market transition is a phenomenon that has been dubbed "disorganization" in the literature and refers to the inability of the new, unstable institutions of the market economy to support long and complex production chains (Blanchard and Kremer 1997).

Figures 3b and 3c show the periods of recovery growth and post-crisis stagnation. Figure 3b suggests that, with few exceptions, the period of recovery growth occurred during the productivity acceleration, with Russia clearly leading the way. Most of the points lie above the bisector, and the points representing alternative estimates for Russia are in the upper left part of the diagram. A possible explanation for this general trend in (Voskoboynikov 2023) is the special role of some high-tech manufacturing industries, which benefited from the adaptation of more advanced technologies made available to them through integration into the global market and foreign direct investment. Finally, the last stage, the post-crisis stagnation of the 2010s, is an episode common to all countries under consideration. All sample countries without exception are plotted below the bisecting line. At the same time, in contrast to Fig. 3a, productivity growth remains positive.

The presented example demonstrates that comparisons over long time intervals allow to detect common trends in productivity dynamics even with relatively crude measurement methodology and different estimation approaches used in different papers.

Technology and Economic Growth. General Purpose VS Special Purpose Technologies

How to isolate general-purpose technologies, which are crucial for economic growth, from special-purpose technologies, which have narrow applications? The issue has not been fully resolved to date. Specific attributes of GPT have been identified (Table 1), but not all technologies claiming to be GPT fit into this category. However, it is tempting to recognize a GPT at a relatively early stage of its development. The lifecycle of such technology spans decades. Throughout its life cycle, GPT can contribute to growth or even inhibit it. Improving the system of definitions is an important objective of the project.

Table 1
Technologies and their matching with GPT attributes

	Various sectors	DYNAMISM	Complementarity	Growth impact cycle	Mastery premium	No substitutes	Matches
Wheel	+	±	+	?	?	+	3–4
Rail transport	+	+	±	?	+	+	4–5
Steam engines	+	+	+	±	+	+	5–6
Electricity	+	+	+	+	–	+	5
Computers	+	+	+	+	+	+	6
Internet	+	+	+	+	+	+	6
Nuclear energy	–	+	±	–	+	–	2–3
Quantum computing	+	+	?	?	?	±	2–3
Nanotechnologies	+	±	?	?	?	+	2–3

General-Purpose Technologies and Human Capital. The Mystery of Interaction

GPT interact with human capital. This interaction may help to accelerate growth. The work of Aguillon, Howitt and Violante continues the possible mechanism of such interaction. The authors argue that the more educated a population is, the easier it is for it to embrace new technology and work with it. In this regard, the more “general” the technology is, the more attractive it becomes for the population to invest in mastering this technology. Workers who are better trained in this way receive a “mastery premium” because they can work with the new technology in different industries. The return per unit cost of mastering such technology is higher than for special-purpose technology, as the worker incurs lower costs when changing jobs and moving to a new field. The process of adjusting knowledge and skills to changing market needs is less costly.

This mechanism underscores the importance of timely GPT identification and integration of its elements into educational programs.

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