

## Human capital in the 21st century: structure, challenges and economic growth

### Abstract

*This article examines demographic change, both globally and in the context of the wider region of Europe, paying specific attention to the situation in Bulgaria which has been experiencing a deteriorating demographic situation. Uneven economic development between will lead to significant changes in demographic structure and, if Europe continues to rely solely on its own human capital, it will face severe demographic decline in contrast to Africa and Asia whose influence and relevance will increase. Meanwhile, the idea that artificial intelligence will benefit everyone is controversial: historical evidence shows that significant growth occurs only in the presence of specific, favourable conditions and in a specific demographic environment. Currently, limited competition between employers, workers having weak collective power, and massive and continuous digitalisation being carried out with neither strategic planning nor control, mean that those with access to cutting edge technologies will gain competitive advantage and that this is likely to result in a further entrenchment of global inequality and wealth concentration.*

**Keywords:** *human capital, economic growth, demographic change, inequality, artificial intelligence*

### Introduction

The Doomsday Clock is a symbolic construct illustrating the assessment of the risk of global catastrophe caused by human activity. The concept was created in 1947, shortly after the end of World War II, by scientists involved in the Manhattan Project (Bulletin of the Atomic Scientists n.d.). The clock functions as a metaphor, not a literal prediction, and serves to visualise the threats to humanity arising from the uncontrolled development of science and technology.

The metaphor is statistical and hypothetical in nature, with the symbolic hour of ‘midnight’ indicating the onset of global catastrophe. The distance to midnight – expressed in minutes or seconds – is updated annually in January based on an assessment of various threats. Among the factors considered in the analyses are nuclear war and climate change, but the risks associated with artificial intelligence have also been added to them as have, subsequently, additional components such as demographics and demographic trends.

When it was first set in 1947, the Doomsday Clock read that it was seven minutes to midnight, since which time its hands have been moved back eight times and forward seventeen, reflecting the dynamic changes in global security and sustainabil-

ity. The greatest deviation from the symbolic hour was recorded in 1991, when the hand was positioned at 17 minutes to midnight – a period coinciding with the end of the Cold War and the signing of a number of key arms control agreements. By comparison, as of January 2025, the time to midnight has been reduced to just 89 seconds – the closest value recorded to date.

In view of the growing global challenges, the symbolism of the clock is becoming increasingly relevant. While the risk of nuclear war is increasingly central to existential threat scenarios, demography – a less discussed but extremely important factor – also deserves attention. In the long term, demographic processes have the potential fundamentally to transform the existing global social, economic and ecological order. Under certain conditions, demographic processes could even contribute to the evolutionary decline or extinction of the human species if they are not adequately analysed and addressed.

The purpose of this article is to examine changes in human capital across continents and globally. Before that, however, it undertakes a brief theoretical overview of what human capital is and how it has evolved over the years.

### Literature review

There are different types of capital – physical, financial and human – with each of the types having different characteristics. At its core, human capital deals with the state of demography in which it represents a unity between biological, social and psychological forms of organisation, marked by the sign of scarcity in resource terms (Kazakov 2001). Human capital is invariably linked to economics as well as to demography, with economists using it to denote those personal qualities which are considered useful in the production process, including knowledge, skills, know-how, good health, education, etc. both at individual level and at aggregate/collective level. In other words, human capital corresponds to any of the stock of knowledge or characteristics that a person possesses – regardless of whether they are innate or acquired – that contribute to his or her ‘productivity’ (Kazakov 2001).

Adam Smith (1776) considered the concept of capital as “the acquired and useful abilities of all the inhabitants or members of society”, defining capital as a stock that brings income to its owner. Alfred Marshall (Cavalieri 1992) made a similar statement, according to which capital includes all economic goods that bring income. Refracted through the prism of demography, Smith’s and Marshall’s statements can be interpreted as follows – the economic well-being of a given country is directly dependent on the availability and condition of human capital (i.e. the condition of demography).

According to Marshall (Cavalieri 1992):

... the development of the human race is an increase in its numbers, strengthening of health and strength, multiplication of knowledge and abilities, enrichment of the characteristics of its character.

Marshall’s judgment examines the relationship between the reproduction of people as a biological species and the related economic activity, which determines the

reproduction of the labour force and the formation of human capital. From this it should be concluded that human reproduction is a fundamental factor in economic and social development.

However, when the process of reproduction is not balanced (i.e. when there is overpopulation or underpopulation), problems arise, in particular the impossibility of achieving an economic optimum (Becker 1993). Qualitative and quantitative human capital is necessary for the development of any economy. In other words, for an economy to grow, it must have an educated and qualified resource of people that is capable of productivity (Dulevski et al. 2016). However, when a country is in a demographic crisis, the following problem is observed – the quantity of human capital decreases significantly and, with it, so does the percentage of the workforce that has the potential to become highly educated and highly qualified (i.e. the quality decreases).

New technologies and the ever-increasing standard of living are often accompanied by changes in the total labour force due to population ageing and declining birth rates (Galor et al. 2000). There is a change in the ratio between adolescents, workers and pensioners, which is an expression of one of the most important and objective macroeconomic characteristics for the respective society. Thus, nations which are ageing are forced to place a higher burden on their pension, health insurance and social security systems insofar as the specific problems associated with the ‘third’ age objectively require this. However, the lower number of adolescents increases their marginal utility according to basic microeconomic theory (Goldin et al. 2008).

The growth of human capital can be captured as an increase in the qualifications, status and/or skills of an individual, such increases making humans more valuable in terms of various economic, social and personal plans (Becker 1964). But, in an ageing nation this is difficult to implement due to the ongoing processes of the depreciation of human capital, which is a significant problem: the depreciation of human knowledge – a core component of human capital – occurs every 4–6 years.

The depreciation of human capital is also related to difficulties in quickly perceiving new information, often related to the age characteristics of individuals (Blundell et al. 1999). Young and unencumbered individuals are generally capable of perceiving new paradigms in science and new views/phenomena in the political sphere. Dynamic life requires constant change and adaptation, which are associated with the rapid acquisition of new knowledge and/or skills, characteristics that are challenges for nations with ageing populations and negative demographic growth.

Another key issue in nations with these problems is the mobility of human capital, which is related to its formation and use, and the investments which are made in facilitating geographic mobility – all essential elements of human capital theory (Mayo 2012).

The main trouble that states encounter in their efforts to form and preserve/retain human capital relates to the problem of emigration, or the practice of ‘brain theft’ (Becker 1983). Here, the ‘thieves’ are those highly developed countries that aim to attract high quality, and highly qualified, specialists by offering them better financial, living, creative, etc. conditions in exchange for their labour. This process of ‘theft’ cannot be limited or regulated because it is economically determined on an entirely

bilateral basis – ‘thieves’ are looking for high quality human capital; and highly qualified specialists are looking for opportunities to express themselves and improve their standard of living.

Consequently, a person who decides to emigrate to a country with a highly developed market structure does the following:

1. he or she creates a conflict of interest between him/herself and the original investor (usually, this is the state)
2. she or he increases the return on her/his own investment because s/he then pursues a career in a society with a high level of income
3. he or she realises external benefits because he or she ends up in a highly developed society to whose prosperity he or she had not contributed up to the moment of emigration (Kazakov 2010).

Human capital is an element of national wealth on which powerful emigration flows have a detrimental impact.

The twenty-first century is one of rapidly emerging technological innovations. Technologies are increasingly used both in the work environment and in everyday life, and their optimal use requires technically literate human capital (Huseinovic 2017). In the context of high technologies, including AI, the discrepancy between individual representatives of human capital is of essential importance.

‘High’ technologies and human capital can be considered in two directions. The first is related to the limitations that arise for some people as a result of these ‘high’ technologies. High-tech innovations created by talented and highly intelligent workers limit the development of (less) talented and (less) educated individuals (Huseinovic 2017) as a result of the potential of ‘smart’ technologies to replace a number of activities performed by (less) educated labour. At the same time, the low-skilled and lesser-educated may hinder the spread and widespread use of ‘high’ technologies mainly due to low educational achievement preventing them from operating such technologies and maximising the benefits of their creation (Pogatsnik 2021). In this case, even if a given technology is useful for the wider community, if a majority oppose its use and implementation then the benefits will be insignificant in terms of improving the level of human wellbeing.

## Population and population growth

If we assume that humans have been around for approximately 50,000 years, the assumption of a constant rate of demographic growth throughout different historical eras – in conjunction with an awareness that the available data on ancient populations are approximate – it has been calculated that the total number of people born who have ever lived is about 106 billion (Population Reference Bureau n.d.). The current living population, amounting to approximately eight billion people, thus represents only about 6 % of all those who have ever existed. This statistical view is the broad basis for a more in-depth analysis that needs to be developed in view of the structural, social and biological consequences of our demographic dynamics.

The global population reached one billion people for the first time in 1804, an achievement that resulted from millennia of biological, cultural and technological

evolution which gradually created the conditions for the sustainable and simultaneous coexistence of such a number of people. Despite slow demographic growth in previous eras, population dynamics are now undergoing a drastic transformation. In the main, this transition is due to deep structural changes brought about by industrial revolutions, subsequent digitalisation and the processes of globalisation and accelerated urbanisation. It is these factors that are contributing to a significant increase in productivity, an extension of life expectancy and the intensification of migration flows which, together, are leading to an exponential growth in the global population.

The accelerated demographic expansion in the modern era is shown by the time interval required for the global population to rise from one to two billion people. This increase occurred within a mere 126 years, with the two billion threshold being reached in 1930. Subsequently, demographic growth accelerated significantly, while the years required for each subsequent billion have decreased dramatically – 30 years to reach three billion (1960), 14 years to reach four billion (1974) and then just 12 years to reach five billion (1986).

Contrary to these trends, however, 1986 marked a turning point after which the rate of positive growth stopped increasing and stabilised in a demographic ‘plateau’. Empirical evidence for this transition is the uniform period of 12 years required to reach each subsequent billion: six billion people in 1998, seven billion in 2010 and eight billion in 2022.

Recent United Nations population projections show that this demographic ‘plateau’ is expected to be surpassed in the current century: models indicate that the rate of growth will gradually slow down, leading to an extension of the time required for the population to increase. It is projected that it will take about 15 years to reach nine billion people (around 2037) and approximately 23 to move to ten billion (around 2060) a trend which is driven by a steady fall in the rate of positive natural economic growth. Whereas in the middle of the 20<sup>th</sup> century, global annual growth varied between 2 % and 2.5 %, by 2025 it had fallen to about 0.8 % – i.e. a threefold decrease within a few decades.

It seems that, by the end of the 21<sup>st</sup> century, humanity will enter a new demographic phase marked by negative demographic growth. According to the estimates of the UN, the global population will begin to decline, for the first time since systematic demographic statistics have been kept, at a rate of approximately -0.1 % to -0.2 % per year. In other words, upon reaching the threshold of ten billion people the human population will enter a phase of gradual numerical decline, which is likely to deepen towards the end of the century.

In the light of these demographic projections, a number of classical economic theories are being rethought. One of the most influential early works in this field was *An Essay on the Law of Population*, published in 1798 by Thomas Robert Malthus. His theory was that, if limits were not imposed on demographic growth, humanity would face an inevitable catastrophe since, while population grows geometrically, food supplies grow arithmetically. This discrepancy, in his opinion, would lead to mass starvation, poverty and social upheaval.

However, modern data highlights that Malthusian logic was either only partially valid or applicable only within a limited historical context – that is, approximately until the end of the 21<sup>st</sup> century. The main factor that Malthus did not take into account is the impact of technological and economic progress – industrialisation, the modernisation of agriculture, improvements in health and education, and global urbanisation. It is this progress that is leading to significant structural changes in demographic behaviour, including a decline in fertility and an increase in life expectancy, which is ultimately causing the reversal of the demographic curve. In addition, such processes are giving rise to an increasingly pronounced global polarisation – with sharply contrasting demographic trends emerging between developed and developing regions.

Digitalisation, the main driver of the fourth industrial revolution, is arising as a factor having a profound impact on the global dynamics of demographic change. Unlike previous industrial revolutions, which were accompanied by exponential population growth due to improvements in healthcare, agriculture and living conditions, the current technological era – built on artificial intelligence, automation, the internet of things and biotechnology – is likely to lead to the opposite effect: a decline in fertility and the onset of negative demographic growth. The reasons for this are complex and include increasing levels of education (especially among women), greater labour mobility, changing life priorities, the growth of individualist culture and the replacement of traditional social structures by digital technologies. As a result of these factors, demographic trends are changing not only on a global scale, but also with clear regional differentiation.

Table 1 – World population by region, 1950–2050

	Population (1950)	% of global population	Population (2050)	% of global population
Asia	1,368,075,415	54.9	5,280,378,401	54.6
Europe	548,867,473	22.0	703,027,759	7.3
Africa	227,776,419	9.1	2,466,647,618	25.5
North America	168,009,338	6.7	426,579,885	4.4
Latin America and the Caribbean	167,782,158	6.7	730,056,747	7.6
Oceania	12,582,044	0.5	57,668,178	0.6

Source: UN demographic database; author's own calculations.

As presented in Figure 1, the relative share of the world's population living in Europe is expected to decrease significantly – from 22 % in 1950 to only 7.3 % in 2050. Demographic dynamics are developing in the opposite way in Africa where, it is predicted, 25.5 % of the world's population will live by 2050 compared to just 9.1 % in 1950. By the middle of the 21<sup>st</sup> century, over 80 % of the global population will live in Africa or Asia.

Table 2 – Projections of population change in the first half of the 21st century, by region

	2000 (bn)	2050 (bn)	Percentage increase
Asia	3.7	5.3	43
Africa	0.8	2.5	212
Europe	0.7	0.7	0
Latin America and the Caribbean	0.5	0.7	40
North America	0.3	0.4	33
Oceania	0.03	0.06	100
Total	6.1	9.7	60

Source: UN demographic database; author’s own calculations.

Figure 2 reveals distinct differences in expected demographic growth between continents in this period. Globally, positive demographic growth is observed in all regions with the exception of Europe: the population of Europe is characterised by staticity – both in terms of absolute numbers and in terms of growth rate.

The population in Europe is expected to remain practically unchanged within these five decades. The average age of the European population is currently around 42, with only 16 % of the population under 15 years of age. Moreover, by the end of the 21<sup>st</sup> century, the average age in Europe is expected to reach between 48 and 50. These demographic trends put Europe in a unique position: not only is the continent the fastest shrinking in the world, it is also the only one that stopped recording positive natural growth at the end of the 20<sup>th</sup> century. In addition, an ageing Europe faces serious challenges related to its social, economic and health systems.

Meanwhile, the opposite trend is observed in Africa, where extremely intense demographic growth is predicted with the continent’s population projected to grow by approximately 212 %, an unprecedented rate in modern demographic history. This rapid growth is also accompanied by a very low median population age: by 2025, the median age in Africa will be approximately 18 years, while the proportion of people under 15 will amount to 45 % of the total, indicating not only a very young population but also raised expectations of future demographic reproduction.

In Asia, the demographic profile is showing signs of a transition towards a more mature (i.e. ageing) population. The median age on the continent is around 31, with 24 % under the age of 15 – a significantly lower proportion than in Africa, but still indicative of a youthful demographic structure.

In North America, the median age is reaching 35 years, reflecting an advanced stage of the transition towards population ageing. Similar values are observed in Latin America (31 years), as well as in Oceania (32 years), where the trends are similar – moderate ageing accompanied by a stabilisation of the birth rate.

These differences highlight a global demographic asymmetry which is becoming increasingly apparent: developing regions, especially Africa, will play a more and more central role in the future structure of the world population; while developed and ageing societies will face significant socioeconomic challenges related to maintaining sustainable growth, balanced labour markets and adequately resourced social systems.

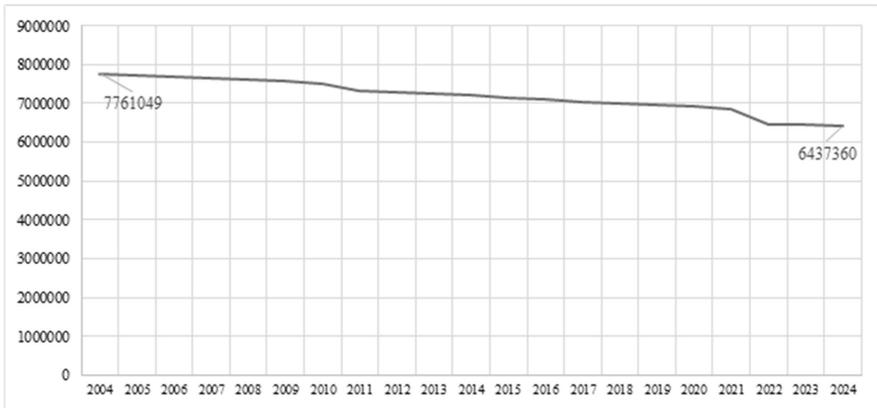
### The Bulgarian context

In different historical periods, Bulgaria has recorded significant demographic growth. During the reign of Prince Alexander Battenberg (1879–1886), the population increased by 57 %, under Tsar Ferdinand (1887–1918) by 54 % and under Tsar Boris III (1918–1943) by 45 %; during the period of socialist rule (1944–1989), there was an increase of 18 %.<sup>1</sup>

In sharp contrast, since 1989 the country's population has decreased by approximately 30 %, <sup>2</sup> indicating a lasting and deepening demographic crisis. This should be seen as a threat of a national nature. It represents a long-term structural problem, the roots of which can be traced back more than three decades. Over the twenty years to 2024, the population of Bulgaria decreased by 17.1 % (Figure 1), with the country's population dropping by approximately 60,000 people per year – equivalent to a city the size of Veliko Tarnovo. This comparison emphasises the scale and dramatic nature of these processes.

- 1 Data sources: 'A look into the archives: the population of Bulgaria', accessed 8 September 2025 at: <https://profit.bg/article/2024012510151018852>; Bulgarian population (1887–2011), accessed 8 September 2025 at: <https://www.infograf.bg/article/1496042439000>; author's own calculations.
- 2 All demographic stats in this para.: National Statistical Institute, 'Demographic Statistics', accessed 8 September 2025 at: [https://infostat.nsi.bg/infostat/pages/module.jsf?x\\_2=4](https://infostat.nsi.bg/infostat/pages/module.jsf?x_2=4); author's own calculations.

Figure 1 – Population of Bulgaria (2004–2024)



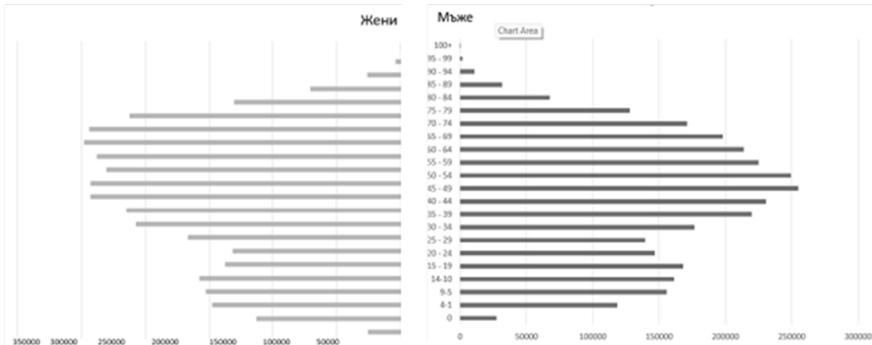
Source: National Statistical Institute demographic statistics; author's own calculations.

Furthermore, in 2024, a total of 100,736 people died in Bulgaria: 275 people per day (366 days in 2024), or 11 per hour. In comparison, live births were just 53,428: 145 babies per day, or six per hour. Twenty years earlier, in 2004, the number of deaths was 110,110: 301 people per day, or 13 per hour. The number of live births in Bulgaria in this year was 69,886: 191 babies per day, or eight per hour. The number of deaths was higher in 2004 than in 2024 (9.3 % more) – but there were 30.8 % more live births.

When examining the age pyramid of the population (Figure 2) – women on the left, men on the right – it is striking that the largest share of the population falls in the age range of 45–49, with the number of men in this group being greater than that of women. There is also a trend for the number of newborns to be the third smallest, ahead only of the age group of people over 100 years old and that of those aged 95–99.

The age pyramid expresses the worrying trend of a country with an ageing population and negative demographic growth. If timely measures are not taken to address the demographic crisis, these negative trends will become irreversible, putting Bulgaria on the verge of a national catastrophe. Despite the urgency of the problem, effective political measures to address the problem are not being taken since the time horizon of a single government mandate (usually 4–5 years) does not coincide with the long-term nature of demographic processes.

Figure 2 – Age pyramid of the population (2024)



Source: National Statistical Institute demographic statistics, author’s own calculations.

### Why is it important for a nation to be young?

This has importance because a significant proportion of discoveries, breakthroughs and achievements are made by people under the age of 40. A few examples will suffice:

- Thomas Edison invented a carbon filament light bulb that burned for 40 hours in 1876, when he was only 32
- James Watt improved the steam engine and gave impetus to the entire industrial revolution in 1765 at the age of 29
- Eugenio Barsanti created the internal combustion engine in 1853, when he was 32
- Johannes Gutenberg, the father of the printing press, invented it when he was 39
- Alexander Graham Bell invented the telephone in 1876, when he was 29
- Nikola Tesla invented the alternating current electrical system and wireless radio at 37. A few years earlier, when he was 31, Tesla had also invented the induction motor (1887)
- Charles Goodyear discovered the process for vulcanizing cast iron at the age of 39
- Albert Einstein created the theory of relativity (1905) when he was just 26
- Dimitri Mendeleev created the Periodic Table of Chemical Elements (1869) at 35
- Niels Bohr discovered the model of the atom in 1913 when he was 28
- James Watson and Francis Crick discovered the structure of DNA in 1953 when they were 25 and 37 respectively
- Blaise Pascal discovered the principle of hydraulics in 1647 when he was just 24
- Michael Faraday made his discoveries in electromagnetism in 1821 at the age of 30
- Guglielmo Marconi, the father of radio, was 21 when he invented it (1895)

- John Atanasoff began work on the first computer when he was 36 and, by the age of 39, he had built it (in the late 1930s)
- Robert Oppenheimer created the atomic bomb between the ages of 36 and 40.

Very many of the most significant scientific and technological discoveries that have driven the world forward and enabled consistent economic development and transformation over the past few centuries have been made by individuals below the age of 40. Human capital depreciation means that, as people age, many gradually experience physical and cognitive decline, increasingly limiting their ability to innovate and be productive.

On the continents of Africa, Asia, South America, North America and Australia, the median age of the population is below 40. In addition to a low median age, Africa also reports an annual natural growth rate of over 2 %.

In Bulgaria, neither factor – median age nor economic growth rate – is met; a worrying factor that raises uncertainties about Bulgaria's demographic, economic and social wellbeing and, ultimately, concerns related to the future of the country.

## Conclusion

These data raise important questions of global significance: while the present belongs to well-developed regions, who will own the future? Are the observed processes reversible? Moreover, what will be the role of artificial intelligence by the end of the 21<sup>st</sup> century?

Global gross domestic product (GDP) in 2025 is estimated at approximately 110 trillion dollars, of which approximately 38 trillion are concentrated in the US and the EU27. Mathematical calculations show that less than 10 % of the world's population currently owns 36 % of the world's GDP, with all 2,700 billionaires in the world combined owning approximately 14 trillion dollars (approximately 12 % of global GDP). If we take into account official forecasts for the number and structure of the population by the end of the 21<sup>st</sup> century, by 2100 some 5–6 % of the world's population will own approximately 45 % of its GDP. This means increasing concentration of capital in the hands of fewer and fewer people, regional and global inequalities and an intensification of contradictions and conflicts of all kinds.

The idea that artificial intelligence will benefit everyone is not only false but dangerous: significant economic growth, or 'economic miracles', occur only in the presence of specific, favourable conditions. Such processes do not occur in environments characterised by limited competition between employers, workers having weak or absent collective power, and where massive and continuous digitalisation is being carried out with neither strategic planning nor control. It is those economic entities that gain first access to cutting-edge technologies that will have a significant competitive advantage over other participants in the global economy.

Uneven economic development between continents will inevitably lead to significant changes in the global demographic structure. If Europe continues to rely solely on its own human capital, it will face serious demographic decline by the end of the 21<sup>st</sup> century, unlike Africa and Asia, whose importance will increase. This trend carries a number of risks, including the possibility of increased migration flows,

economic shocks and even military conflicts arising from growing tensions between regions with different demographic and economic potentials.

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