# 1 As an Introduction

The interplay between technology and economics has been a subject of ongoing debate. This complex issue encompasses ethical and moral considerations alongside the economic and social implications that have become increasingly prominent since the First Industrial Revolution. A central question remains: does innovation universally benefit employment and wages, or are its effects contingent on specific regions, sectors, and timeframes?

This book posits that several significant recent trends – jobless growth, the great decoupling, and the decline of labour share – are not universal phenomena but rather time-limited and spatially specific empirical observations. This is partly attributable to the interaction between technological innovation and institutional factors (including economic governance structures, institutional arrangements, and policy decisions), which profoundly influence the developmental trajectories of economies.

Technological change, to paraphrase Schumpeter, disrupts existing systems, leading to the creation of new ones. As the engine of economic growth, technological innovation alters the balance of power between countries and social classes and within families, impacting structure and individual roles. Despite the magnitude of these changes, quantifying the precise effects of technological advancements on various markets remains challenging. Solow (1965, p. 18)[1] himself questioned the net impact of automation on job creation and destruction, acknowledging the inherent ambiguity surrounding this issue. This book aims to provide a qualitative and quantitative analysis of this question by examining the impact of automation technologies on employment and wages (Compagnucci et al., 2019, 2021; Gentili, 2022; Valentini et al., 2023).

[1] 'Perhaps the question – Does automation create or destroy more jobs? – is answerable in principle; perhaps it is not.'

While acknowledging the long-term contribution of innovation to economic well-being, this volume diverges from the prevailing discourse of the 1980s by focusing on the complex interplay of factors underlying these phenomena. If, as neoclassical economics and mainstream growth theory assert, technological innovation drives long-run growth, why has the surge of innovations since 1980 (computers, microelectronics, the internet, ICT, GPS, mobile phones, smartphones, robots, etc.) coincided with a persistent slowdown in GDP per capita growth in advanced economies?[2] This 'puzzle' invites further investigation into the limitations of neoclassical theories, the roles of international trade and globalisation, the influence of theoretical approaches like Supply Side Economics, Monetarism, and New Classical Macroeconomics, and the impact of their associated economic policies. Additionally, it prompts consideration of factors such as 'jammed' structural change and outdated institutional arrangements.

These questions are central to economic and policy debates at both national and supranational levels, with implications for human capital accumulation, the role of economic policies, wealth distribution, and the relationship between growth and aggregate demand. This book offers a structuralist interpretation of ongoing changes, where economic performance is viewed as contingent upon the evolving conditions of the social and economic environment. Specifically, it argues that the outcomes of different economic systems, particularly in employment and income (both level and distribution), are closely tied to their historical development, policy choices, and the innovative environment in which they operate.

The profound transformations brought about by the current technological advancement phase in our professional and personal lives are at the centre of intense debate. While there is widespread agreement that robots and artificial intelligence (AI) will impact every facet of our existence (Hägele et al., 2016; Huang and Rust, 2018; Makridakis, 2017; OECD, 2018a), there is less consensus on how these changes will affect employment and wages. As Dosi and Virgillito (2019, p. 594) highlight, new technologies could usher in an era of prosperity and social inclusion, or conversely, one of mass unemployment, inequality,

[2] In OECD countries, the growth rate of GDP per capita was 3% between 1960 and 1969, and then steadily declined: 2.5% between 1970 and 1979; 2.1% between 1980 and 1989; 1.8% between 1990 and 1999; 1.2% between 2000 and 2019. www.oecd.org/en/data/indicators/nominal-gross-domestic-product-gdp.html

and social exclusion, potentially leading to a 're-feudalisation' of Western societies. This spectrum of possibilities has led to a wide range of predictions, from optimistic to pessimistic, which is unsurprising given the complexity and pervasiveness of the ongoing transformation (Korinek and Stiglitz, 2025).

The European Commission (EC, 2019) designs two potential scenarios. The first, a pessimistic outlook, suggests that robotisation and AI-based machine learning will enhance machines' predictive and decision-making capabilities, leading to a substitution effect that outweighs any complementarity between machines and workers. This could result in significant job losses and displacement of certain types of workers, potentially causing negative medium- to long-term effects on employment and wages. Additionally, there is the risk of negative impacts on aggregate demand (Bessen, 2019) and, consequently, on the economy's capacity for growth, potentially leading to extended periods of stagnation (Delli Gatti et al., 2012). The second, a more optimistic scenario, posits that robots and AI will increase labour productivity due to the complementarity between machines and humans. In this scenario, workers will benefit from the ability of machines to perform routine tasks, freeing up their time, resources, and energy for social and intellectual work. Two potential effects on wages are anticipated: workers in jobs complementary to technologies will experience a substantial increase in wages. At the same time, those replaced by machines will face lower wages and fewer job opportunities.

This dichotomy in views contributes to the wide range of predictions regarding the Fourth Industrial Revolution. Technological change produces varying effects depending on the specific time and sector affected by innovation (Bessen, 2019). The overall impact on an economy is further influenced by the relative weight of the sector in question (Gentili et al., 2020) and the ability of technology to generate new occupations that are 'better' than those lost to automation (Acemoglu and Restrepo, 2020). These effects, therefore, differ between countries and regions due to variations in economic specialisation, development stages, and growth patterns (Acemoglu, 2002a, 2015). Ultimately, the automation process could exacerbate existing spatial inequalities (Giaoutzi and Stratigea, 1991; Sujarwoto and Tampubolon, 2016), already pronounced between and within countries.

In general, technological innovation has the potential to bring improvements for all. However, for this to occur, the innovation

process must be supported by public intervention (Mazzucato, 2013), and its impacts must be carefully managed and directed by public institutions and policies (Bruckner et al., 2017; Rodrik and Sabel, 2022; Rodrik and Stantcheva, 2021). If left solely to market forces, there is an increased risk of polarisation and social disruption.

The economy is a complex system that evolves due to technological innovations and the co-evolution of institutions (Acemoglu and Robinson, 2010; Bowles, 2004; Landesmann and Pagano, 1994). Technological innovations influence the interactions within and between economic systems, producing complex effects, since the economic system is non-reducible, that is, aggregate behaviour is not equal to the sum of individual behaviours. It follows that there are no laws in economics, only stylised facts. There are no Popper-like falsifications in systems where the continuous introduction of innovations and the flow of new information mean that boundary conditions constantly change, rendering the series non-ergodic and Bayesian statistics useless.

## 1.1 Jobless Growth

The concept of jobless growth and labour dislocation, while discussed for approximately two decades (see, among others, Acemoglu and Autor, 2011), presents a challenge to mainstream economic thought. Okun's Law, a cornerstone of economic literature for half a century, posits a relationship between unemployment and GNP, stating that 'in the postwar period, on the average, each extra percentage point in the unemployment rate above four per cent has been associated with about a three per cent decrease in real GNP' (Okun, 1962, p. 135). However, recent empirical evidence suggests a departure from this established relationship.

**Box 1.1** Kaldor and stylised facts

In its pursuit of emulating the hard sciences, economics has often approached socio-economic reality by treating empirically observed relationships and phenomena as immutable laws akin to those in physics. However, economic relationships are inherently mutable. As social contexts evolve in response to environmental conditions,

so does economic agents' behaviour within those contexts, mainly where interaction occurs. Empirical evidence emerging since the 1990s challenges some of the stylised facts presented by Kaldor in his 'Theory of Capital' (1961). While Kaldor identified six such facts, Jones and Romer (2010), half a century later, proposed six more that often contradict Kaldor's original observations. Furthermore, five years later, Stiglitz (2015a, b, c, d) presented five stylised facts related to income and wealth inequality, echoing themes explored by Piketty (2013). Stiglitz (2015a, p. 2) emphasises that 'some of these "facts" are truer for some countries than others, and there are a few country exceptions'.

Table 1.1 compares the stylised facts proposed by Kaldor (1961) and Jones and Romer (2010). The enduring influence of Kaldor's stylised facts is partly due to their correspondence (5 out of 6) with those underlying Solow's (1956) and Swan's (1956) exogenous growth model. However, it is crucial to note that Solow himself

**Table 1.1** ***Stylised facts from Kaldor (1961) and Jones and Romer (2010)***

| | Stylised facts – Kaldor (1961) | New stylised facts – Jones and Romer (2010) |
|---|---|---|
| 1 | Labour productivity has experienced sustained growth. | Accelerating growth. |
| 2 | Capital per worker has also consistently increased. | Increases in human capital per worker. |
| 3 | Real interest rates have remained consistent. | Increases in the extent of the market. |
| 4 | The capital–output ratio has demonstrated consistent stability. | Substantial income and total factor productivity (TFP) differences. |
| 5 | The respective shares of capital and labour in national income have remained consistent. | Long-run stability of relative wages. |
| 6 | Growth rates exhibit significant variation among the world's fastest-growing economies, typically within a range of 2–5 per cent. | Variations in recent growth rates. |

stressed the need to endogenise innovation, moving beyond the notion of mere chance as an explanation for economic development. This would have necessitated incorporating an additional concept into the existing framework of capital (understood as a single factor) and its substitutability with homogeneous labour, all embedded within an aggregate production function whose form was exogenously determined by technological progress (cf. Jones & Romer, 2010, p. 226). Moreover, introducing a more nuanced analysis based on endogenous production functions could only have undermined the analytical validity of the neoclassical production function (Dosi, 2023).

In contrast to the exogenous Solowian approaches, the endogenous models of Modern Growth Theory emerged as the dominant paradigm for policy and analysis in the latter half of the 20th century. From the simplest AK models (Rebelo, 1991) to more refined formulations (see Galor, 2005 and Acemoglu, 2012), endogenous models continue to serve as the benchmark against which economic analysis is evaluated. However, none of these approaches can fully capture the complexities of economic growth and development, nor can they adequately analyse the multifaceted effects of innovation.

If the traditional interpretation of Okun's Law were valid, all data points on a graph plotting GDP per capita growth against the change in the employment rate would fall within the first and third quadrants (Figure 1.1). This would indicate a direct correlation: GDP growth corresponds to employment growth, and GDP decline corresponds to employment decline. While this relationship held until the 1990s, it has become less consistent in recent decades, particularly in Western economies. Although most GDP per capita change – employment rate change pairs still fall within the first and third quadrants, this accounts for only about 70% of the total data points. Excluding data from Latin American countries, over a quarter of the points fall within the fourth quadrant, where GDP per capita growth is accompanied by a decrease in employment. These points primarily pertain to the period between 2000 and 2019.

Therefore, the weakening link between economic growth and employment is not limited to post-recession periods, as the concept of jobless recovery might suggest. Jobless recovery refers to the slow

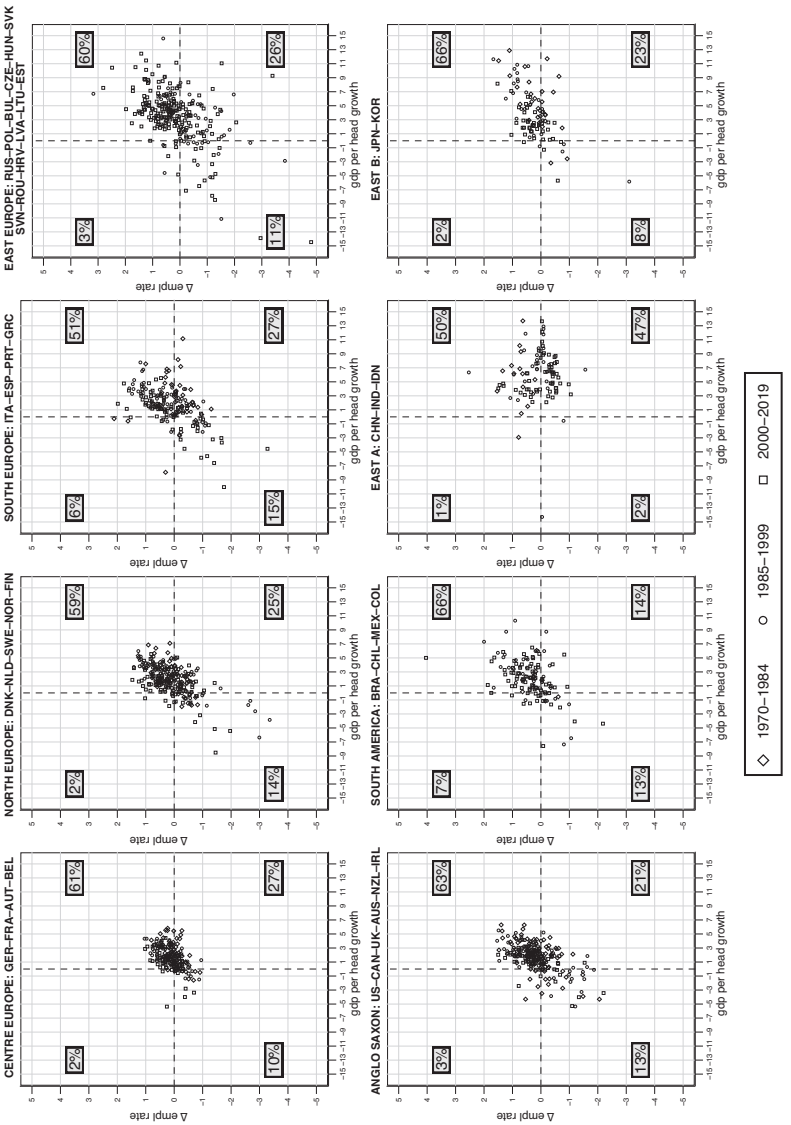


**Figure 1.1** Relationship between GDP per capita growth rate and change in employment rate.
Source: authors' elaboration on OECD data

recovery of aggregate employment relative to the faster recovery of aggregate output observed after recessions in the last forty years (Jaimovich and Siu, 2020). This topic will be revisited later.

In other words, the empirical regularity described by Okun's Law has been subject to scrutiny since the 1980s. As Prachowny (1993, p. 332) noted, Okun's coefficients should be considered within a *mutatis mutandi* framework rather than a *ceteris paribus* one, as they represent a short-term relationship that cannot reliably predict long-term economic and employment trends. Consequently, Okun's Law cannot be considered a law in the same mechanistic sense as those found in the hard sciences. The 1980s marked a turning point, as the previously optimistic view of innovation's impact on economic well-being began to waver. During this period, GDP growth was often accompanied by either stagnant employment or a decline in its growth rate, a phenomenon known as 'jobless recovery' that was previously unfamiliar to economists. In the post-World War II era, there was a noticeable regularity in output fluctuations, with volatility observed in most real macroeconomic variables (McConnell and Perez-Quiros, 2000). Post-crisis periods were typically characterised by high-growth recoveries that generated substantial employment.

Many scholars suggest that this structural break occurred in the first quarter of 1984 in the United States, marking the beginning of the Great Moderation (Kim and Nelson, 1999; McConnell and Perez-Quiros, 2000; Méndez et al., 2016), a period characterised by a significant decrease in aggregate volatility (Faberman, 2017). Since then, recessions have been followed by periods of less pronounced output growth and slow employment recovery, often resulting in jobless recoveries (Bachmann, 2012; Berger, 2012; Morin, 2014). Méndez et al. (2016) calculated that after the 2001 recession in the United States, employment continued to decline for 21 months, resulting in nearly 1.08 million jobs lost before it began to recover. The post-2008 recovery was relatively swift, with employment reaching its lowest point in just 8 months, but it was more severe in quantitative terms, resulting in the loss of 1.26 million jobs.

While there is widespread agreement on the empirical evidence regarding the last three employment recoveries, there is no consensus on their causes. Various explanations have been proposed to

understand the recent post-crisis employment performance, generally categorised as follows:

a) structural change (Autor and Dorn, 2013; Groshen and Potter, 2003; Jaimovich and Siu, 2012);
b) long-term effects of the business cycle (Bachmann, 2012; Engemann and Owyang, 2010);
c) cyclicality of productivity (Berger, 2012; Koenders and Rogerson, 2005; Morin, 2014);
d) changes in labour market institutions (Peck and Theodore, 2007; Schreft and Singh, 2003);
e) stagnation of aggregate demand despite productivity growth (Bessen, 2019; Compagnucci et al., 2020).

It is evident that each of these potential explanations is intertwined with the approaches adopted in public economic governance: the reduced emphasis on supporting aggregate demand by public authorities (in favour of Supply Side Economics), the rejection of industrial policies in the name of competition and efficient markets, the deregulation of markets (mainly financial and labour markets), and the diminishing redistributive role of states.

The trends observed in recent decades represent a more extensive and radical phenomenon than post-crisis periods, shifting the focus from jobless recovery to jobless growth. The explanations proposed for these post-crisis phases are closely linked to the evolving structure of the economy and the challenges of applying policies designed for specific historical problems to new and different situations. Even more complex is the long-term explanation and, therefore, the identification of policies suitable for managing technological change that potentially affects every aspect of daily life, particularly the labour market.

The structural changes in economies are both a cause and an effect of these crises and new phenomena. Technological advancement, endogenous to the economy, brings about paradigm shifts that policymakers cannot ignore. The scale of these changes raises questions about the very existence of specific markets shortly. Without sufficient incomes, how can workers purchase the goods produced (by machines and/or other workers)? This concern extends not only to workers but also to capital holders. If consumers lack income and therefore do not consume, capital does not receive its due returns.

Meade already in 1993 proposed reallocating capital ownership rights to ensure workers receive compensation for income lost through

automation. Meade was concerned that automation would reduce the demand for labour, mainly if the net accumulation of capital equipment resulted in a reduced need for human labour, even considering the growth of the labour force and the displacement of workers from obsolete machinery (Meade, 1993, pp. 25–26). Nonetheless this solution found very limited application in real economy.

## 1.2 The Great Decoupling and the Decline of Labour Share

The phenomenon of jobless growth is closely linked to two other significant trends: the increasing decoupling between productivity and income (often referred to as the Great Decoupling) and the decline in the share of income distributed to labour relative to capital (known as the decline of labour share). This decline in labour share is inherently related to a decoupling between productivity and wages, as documented by Brynjolfsson and McAfee (2011, 2014), Autor and Dorn (2013), Schwellnus et al. (2018), Autor et al. (2017), and Compagnucci et al. (2021).

Tables 1.2 and 1.3 summarise some long-term dynamics regarding productivity trends (with caveats highlighted in Box 1.2), labour remuneration, labour quantity, distributional conflict (labour share), and inequality.

Several notable regularities emerge from Table 1.2:

(1) a slowdown in hourly productivity growth;
(2) a lower increase in hourly wages compared to productivity;
(3) a decrease in hours worked per engaged;
(4) a decline in the labour share.

These dynamics are sometimes accompanied by variations in the overall quantity of work, measured in terms of total hours worked (labour utilisation) and/or the employment rate. Each economy exhibits its specific patterns given its unique institutional and policy context. Further analysis of these variations will be provided later in this volume.

Furthermore, as shown in Table 1.3, these phenomena are associated with a generalised increase in income inequality, particularly in polarisation (measured as the income ratio of the wealthiest 10% to that of most of the population). This rise in inequality is often observed even after accounting for taxes and public intervention, highlighting the