



The Strategic Transformation of Gray-Collar Workers in the Context of Industry 5.0 and Digitalization

Endüstri 5.0 ve Dijitalleşme Bağlamında Gri Yaka Çalışanların Stratejik Dönüşümü

Abstract

This study aims to examine the position of gray-collar workers in the labor market, their roles, and their functions within organizational structures within the framework of digital transformation and Industry 5.0. Throughout industrial revolutions, production systems, working methods, and labor processes have continuously transformed; particularly with the proliferation of automation, artificial intelligence, big data, and digital technologies, the traditional blue-collar and white-collar distinction has become increasingly inadequate. In this environment of transformation, gray-collar workers, who can use technical, cognitive, and managerial skills together, are emerging as strategic actors who bridge the gap between production and management processes. Within this scope of the research, national and international academic studies published between 2009 and 2025 that focused on the relationship between digitalization, automation, and the labor market were analyzed using a systematic literature review method. In the literature, gray-collar workers are defined as hybrid actors and expert technicians who play critical roles in high-tech processes. The research reveals that digitalization is increasingly replacing routine and standardized tasks, while the demand for workers possessing both technical and cognitive competencies is rising. Despite their pivotal role in bridging production processes and management tiers, gray-collar workers are often relegated to a secondary position in human resource policies. In this regard, the study emphasizes the critical necessity of developing comprehensive human resource management strategies that center on gray-collar workers, support lifelong learning, and strengthen sustainable employment, based on Industry 5.0's human-centered approach.

Keywords: Gray-collar workers, digital transformation, Industry 5.0, labor market, human resources management

ÖZET

Bu çalışma, dijital dönüşüm ve Endüstri 5.0 çerçevesinde gri yakalı çalışanların işgücü piyasasındaki konumunu, rollerini ve örgütsel yapılar içindeki işlevlerini incelemek amacıyla yapılmıştır. Sanayi devrimleri boyunca üretim sistemleri, çalışma yöntemleri ve iş süreçleri sürekli bir dönüşüm geçirmiştir; özellikle otomasyon, yapay zeka, büyük veri ve dijital teknolojilerin yaygınlaşmasıyla birlikte, geleneksel mavi yakalı ve beyaz yakalı ayrımı giderek yetersiz hale gelmiştir. Bu dönüşüm ortamında, teknik, bilişsel ve yönetsel becerileri bir arada kullanabilen gri yakalı çalışanlar, üretim ve yönetim süreçleri arasındaki boşluğu dolduran stratejik aktörler olarak öne çıkmaktadır. Bu araştırma kapsamında, 2009 ile 2025 yılları arasında yayınlanan ve dijitalleşme, otomasyon ile işgücü piyasası arasındaki ilişkiye odaklanan ulusal ve uluslararası akademik çalışmalar, sistematik literatür taraması yöntemi kullanılarak analiz edilmiştir. Literatürde gri yakalı çalışanlar, yüksek teknolojlili süreçlerde kritik roller üstlenen melez aktörler ve uzman teknisyenler olarak tanımlanmaktadır. Araştırma, dijitalleşmenin rutin ve standartlaştırılmış görevlerin yerini giderek daha fazla aldığına, buna karşın hem teknik hem de bilişsel yetkinliklere sahip çalışanlara olan talebin arttığını ortaya koymaktadır. Üretim süreçleri ile yönetim kademeleri arasında köprü kurma konusunda kilit bir role sahip olmalarına rağmen, gri yakalı çalışanlar genellikle ikincil bir konuma itilmektedir.

Anahtar kelimeler: Gri yakalı çalışanlar, dijital dönüşüm, Endüstri 5.0, işgücü piyasası, insan kaynakları yönetimi

INTRODUCTION

First, second, and third industrial revolutions represent historical turning points that reshaped economic and social structures through transformations in production technologies. The first industrial revolution (late 18th century–early 19th century) emerged with the use of steam power in production. Owing to mechanized machines and the factory system, the artisan-based production structure was replaced by industrial production based on standardized work arrangements, division of labor, and hierarchical control. The second industrial revolution (late 19th century–early 20th century) gained momentum with advancements in electrical energy, internal combustion engines, the chemical industry, and communication technologies. As production capacity increased with mass production and

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assembly-line applications, specialized departments and more complex organizational structures emerged in businesses. The third industrial revolution was shaped by the integration of computer technologies, digital electronics, automation systems, and the Internet into production processes. It brought forth a new production and work order in which the importance of information and data management increased, global supply networks developed, and employees were expected to possess digital skills and technical problem-solving competencies. Technological developments have brought about a sociotechnical transformation that not only changes production techniques but also transforms the quality of the workforce, organizational forms, and social structures. (Sott & Kremer, 2026).

Today, a new industrial transformation, known as Industry 4.0, is taking place. Since 2011, the integration of digital industrial technologies into production processes has accelerated, enhanced flexibility, and improved efficiency in factory manufacturing. This process has enabled the production of high-quality products at lower costs. The concept of Industry 4.0 is an inclusive term that refers to the integration of smart production systems, digitalization, and advanced technologies. The digital transformation that has emerged with the rapid development of digital technologies has significantly affected not only production processes but also the economic structure, business models, employee competencies, and working methods. Currently, we have entered an era in which instantaneous access to data is possible, and value creation focused on data and services has come to the forefront, alongside physical products. This transformation paves the way for businesses to restructure their existing business models through digitization and for new organizational structures to emerge in the process. (Yiğit and Engin, 2025).

It is expected that the transformations of Industry 4.0 on technology, production systems, and organizational structures will significantly impact the employment structure and the future of work, particularly in terms of labor demand. Technological developments and changes in market conditions continuously transform employment levels and the structure of economic activities. This process, while reshaping the functioning of sectors in all economies, is causing the emergence of new skill requirements in the labor market. While pessimists argue that Industry 4.0 will lead to significant job losses, on the other hand, optimists claim that Industry 4.0 will create new jobs and employment areas, and therefore, there will be increases in employment.

The widespread adoption of Industry 4.0 technologies has significantly changed the structure of workplaces, the nature of jobs, and the skills required by the workforce. Technologies such as digitalization, automation, artificial intelligence, and machine learning are largely replacing routine tasks that require low skills, while increasing the demand for professions that require advanced digital skills. This situation has led to skills-based divergence in the labor market and raised concerns about job losses in some sectors. However, new professions are emerging in fields such as data analytics, electronic information security, artificial intelligence, the Internet of Things, and software development. With the widespread adoption of technology-intensive work environments, employees are expected to possess digital skills and demonstrate social and cognitive competencies, such as problem-solving, creativity, communication, teamwork, and lifelong learning. Additionally, flexible, remote, and project-based work models are anticipated to become widespread in Industry 4.0 (Görmüş, 2026).

As the final stage of the Industrial Revolution, Industry 5.0 aims to harmonize human creativity with smart, efficient, and precise machines. This approach aims to go beyond the innovations offered by Industry 4.0, increasing efficiency in production processes and providing solutions that are more aligned with user preferences. Industry 5.0, in which humans and robots work in collaboration, aims to provide human-centered solutions. To this end, it seeks to keep humans as part of the production process while increasing productivity (Koska, 2025).

In this process, the transformation of production processes alongside digitalization increases the need for a mid-level workforce that combines technical knowledge with digital competencies. Especially within the framework of the Industry 5.0 approach, the strengthening of human–technology interaction increases the strategic importance of gray-collar workers, who serve as a bridge between technology and human labor in production processes. In this research, focusing on the structural changes triggered by digital transformation and the Industry 5.0 paradigm in the labor market, blue-collar and white-collar distinctions are transcended, and gray-collar workers, who are described as the pillars of modern production processes, are considered the primary unit of analysis.

THE CONCEPT OF THE COLLAR AND ITS TRANSFORMATION

The concepts of ‘collar’ and the classification of workers by color emerged historically, particularly following the First Industrial Revolution. With the Industrial Revolution, the proliferation of large-scale enterprises increased the demand for labor and led to the employment of many workers within the same production systems. During this period, blue-collar workers, who constituted the largest group of employees in the industrial sector, were defined as the workforce primarily engaged in physically demanding jobs and represented a significant part of the labor

movement, especially in the United States. Blue-collar workers, who emerged during the First and Second Industrial Revolutions, are engaged in labor-intensive jobs in production activities and primarily work in the manufacturing sector. This group of workers is generally referred to as such because they wear blue work clothes or overalls that show less dirt and stains and work on an hourly wage system. After World War II, the concept of white-collar workers emerged in the social sciences. White-collar workers refer to salaried professionals who mostly work in office environments and engage in management or clerical tasks. This naming, similar to the case of blue-collar workers, is inspired by the employees' clothing style and originates from the white shirts frequently preferred by professionals (Eriş et al., 2020).

With technological changes, the structure of the workforce has shown differences. These differences have also been reflected in the nature of the work, leading to changes in working systems, wage disparities, and labor laws, resulting in a categorical classification of the workforce based on various collar colors, such as blue, white, and gold (Küsbeci et al. 2022).

In this context, the increase in employees possessing both technical application skills and cognitive/analytical competencies in the production and service sectors, where technological transformation is gaining momentum, has blurred the sharp distinction between blue- and white-collar workers. Thus, gray-collar workers have emerged as a hybrid workforce profile that simultaneously takes on both roles.

Theoretical Foundations of the Collar Concept

With the emergence of large-scale enterprises in the early 19th century, the classical management approach took shape. During this period, planning, record-keeping, the written formulation of organizational policies, and specialization based on the division of labor came to the forefront of management practices. Within this framework, employees were seen as part of a mechanical and closed organizational structure and were positioned to adapt to the functioning of the production system. The strengthening of labor movements in the 1920s and the social changes occurring in large cities made the study of the increasingly alienated behavior of individuals in the workplace an important research topic. With the development of the behavioral management approach in the 1930s, various management tools were developed to help managers understand employee behavior, thanks to the contributions of disciplines such as psychology, sociology, anthropology, and social psychology. (Sözen et al., 2014).

With digitalization and technological advancements, human labor has undergone a transformation due to the technical changes brought about by digitalization. As production systems are sociotechnological systems, both technical and social choices must be made during the design and implementation processes of digitalization. In the field of production, there has been a need to enrich the potential of the work performed by manual laborers, that is, blue-collar workers, to integrate smart resources (machines, workers), products, and processes within and beyond organizational boundaries, and to expand the work of the analytical unit to include white-collar workers who perform supportive tasks, such as job preparation, control, or decision-making. In fact, blue-collar and white-collar jobs in factories are often deeply intertwined at the process level, creating significant interdependencies to understand the anticipated changes (Waschull et al., 2022).

Blue-collar workers: Blue-collar workers primarily perform physical labor and have relatively limited career paths. A particularly strong finding from studies comparing job satisfaction among these groups is that blue-collar workers tend to be less satisfied with various aspects of their jobs, such as their wages, supervisors, and the work itself, than their white-collar counterparts (Çiçek, 2013).

Blue-collar workers are mostly composed of individuals with relatively low levels of education. A significant portion of these individuals, who primarily work in jobs requiring physical labor, enter the workforce at an early age. Their early abandonment of the education process, participation in employment at a young age, and working in various jobs that do not require skills or require low skills are among the main characteristics of this group of workers. It is evaluated that blue-collar workers, who often have living conditions similar to their families' socioeconomic status, have limited opportunities for social mobility. Some believe that the levels of organization and union participation are not at the desired level. Nevertheless, blue-collar workers play critical roles in the functioning of societies and the sustainability of daily life (Çımrın et al., 2023).

White-collar workers: The term white-collar worker is ambiguous. Its meaning varies between countries and can even mean one thing to one person and something else to another within a single country. The confusion surrounding this term is evidenced by the numerous synonyms it has acquired, such as 'salaried employee,' 'office worker,' 'non-manual worker,' and 'white-collar worker.' White-collar workers earn their living not with their hands, but with their minds. These workers, apart from their middle position in society, form a 'new middle class' that does

not possess unique characteristics that can be defined independently. White-collar workers are involved in administrative tasks, design, analysis and planning, auditing and management, and commercial tasks (Bain and Price, 1972).

White-collar workers are generally defined as individuals who perform tasks based on mental labor and specialized knowledge rather than physical labor. These employees mostly possess a certain level of education and are often in positions close to authority within the organizational structure or may directly hold managerial authority. White-collar workers are fundamentally categorized into two main groups: technical and non-technical workers. Technical white-collar workers include professionals in fields requiring specialized expertise and technical knowledge, such as engineers, architects, designers, urban planners, and technicians. In contrast, non-technical white-collar workers are employees who perform more administrative and routine tasks in areas such as office services, management, finance, commerce, media, law, health, marketing, education, and advertising (Erdayı, 2012).

Grey Collar Workers: The term grey collar worker is commonly used in Western countries and organizations to describe the "ageing" or "greying" population in the workforce. However, it is also used to describe employees whose professions are not classified as white- or blue-collar. These are also referred to as skilled technicians. Job descriptions refer to employees who combine white- and blue-collar tasks. Technicians are employees who combine white- and blue-collar tasks in their job descriptions. The term 'grey collar' refers to jobs that require a university degree but fall below the skill level of the employees. (Hutchings et al., 2009). The loss of functionality of the traditional collar distinction due to technological integration has necessitated the definition of a new actor in the labor market that embodies the characteristics of both categories. This gray area, where office-focused management skills intersect with field-focused technical expertise, has led to the emergence of the concept of gray-collar workers, which constitutes the most dynamic layer of modern production systems.

The Conceptual Framework of Gray-Collar Workers

Gray-collar workers are individuals who have gained experience over time while working in the production lines or technical units of businesses. These employees have generally learned work processes over many years, received specific vocational training, and often hold intermediate positions, such as foreman or shift supervisor. In addition to being proficient in the technical aspects of production processes, they have the experience to foresee the workflow within the team, potential errors, and issues in the work processes. Although gray-collar workers often do not undergo formal technical training, such as in engineering, they are quite proficient in the practical knowledge of their field and production processes. Owing to their long tenure in the same establishment, they are among the most trusted employees by employers and can take on an informal leadership role over blue-collar workers on the production floor (Ertürk, 2020:26).

Currently, the production of information and technological developments has reached an extremely rapid and remarkable level. In the information age, digitalization and Industry 4.0 applications are progressing within a structure that supports and strengthens each other. The speed of information growth and its transformation capacity are leading to significant changes in both social structures and working life. The widespread adoption of digitally connected devices and smart systems has brought individuals and institutions into an ecosystem characterized by continuous interaction. In this context, businesses' ability to integrate their existing organizational structures and business processes into digital platforms necessitates the development of strategic transformation plans. The factor that determines sustainable success during the transformation process is not merely corporate size or power; it is the capacity to adapt quickly and flexibly to changes. In today's rapidly digitizing world, businesses must create conditions that support employees' adaptation to new work processes to maintain their competitive advantage and ensure employability (Benk, 2021).

The process of digitalization requires employees to possess up-to-date technical knowledge and competencies in analytical thinking, developing a creative perspective, solving complex problems, and effectively using technology. These new requirements necessitate that individuals possess the capacity for continuous learning and self-renewal; in this respect, they become an advantageous factor that enhances employability. In addition, technology-based transformation leads to a decrease in the demand for jobs based on physical strength and positions requiring mid-level technical skills, causing some professions to disappear; however, it also paves the way for the emergence of new areas of expertise and alternative employment opportunities. With the advancement of digital transformation, it is anticipated that the responsibilities of some professions will be taken over by technological systems and robotic applications, while those professions with the most open and standardizable task structures are considered to have a higher risk of disappearing. However, the acceleration of digitalization also brings with it the possibility of new professions requiring expertise in information technology, software, and technology (Benk, 2021).

This transformation is paving the way for the emergence of a new employee profile that goes beyond traditional blue-collar and white-collar distinctions in the workforce structure. In particular, gray-collar workers, who possess both technical expertise and cognitive and coordination-based competencies, are at the center of digital transformation. Gray-collar workers, while possessing technical knowledge of production processes, represent a hybrid workforce profile that can perform data analysis, interact with digital systems, and contribute to process improvement.

The digital age has significantly stretched the boundaries of time and space, reshaping the understanding of work and production. While industrial models are undergoing transformation, information-based innovations have become prominent in many areas based on human-system interaction. Rapid advancements in digital technologies, such as robotic applications, artificial intelligence systems, smart manufacturing technologies, sensor networks, cloud computing infrastructures, the Internet of Things, and augmented reality, have triggered a new global transformation process through the integrated use of these elements. The complementary nature of these technologies has paved the way for the widespread adoption of digital applications in many fields, from manufacturing to the service sector, and has transformed today's world into a holistic digital ecosystem (Ersöz and Özmen, 2020).

The foundation of Industry 4.0 is digital technologies, and it is expected that the widespread adoption of robotic systems in production processes will create significant transformations in the workforce structure. In this context, it is anticipated that low-skilled jobs are at risk of disappearing; conversely, the new jobs that will emerge are expected to require specific competencies related to robotic technologies, automation systems, and digital infrastructures (Saniuk et al., 2020). Tasks based on repetition and standardization in both the service and production sectors are considered to be among the first jobs to undergo transformation.

In this process, there is also a change in the qualities expected from employees. Creativity, critical thinking, analytical evaluation, and the capacity to solve complex problems are becoming primary competencies. Additionally, individuals need to develop their social, cognitive, and emotional skills, which cannot be easily replaced by machines, to adapt to technological change. Therefore, digital transformation is redefining not only how work is done but also the set of competencies expected from the workforce (Heinrich, 2018).

The widespread adoption of digitalization, automation, and robotics technologies has sparked various discussions and concerns regarding the future of employment and the transformation of jobs. In particular, the development of automation technologies is increasing the demand for professions that require advanced technical knowledge and expertise. In the report titled "Jobs of Tomorrow: Mapping Opportunity in the New Economy," published by the World Economic Forum, the emerging job sectors of the future and the competencies required in these fields have been addressed. The report highlights areas such as sales, marketing, and content production, the care economy, engineering and cloud computing, human and culture management, product development, the green economy, and data and artificial intelligence. Research findings indicate that the demand for human-centered skills will also increase with digital transformation. Employment opportunities are particularly high in fields such as artificial intelligence expertise, data science, customer success expertise, and advanced engineering. In contrast, employment growth in certain professions, such as social media assistance, waste biogas production system technician, wind turbine service technician, and green marketing, may be more limited (Benk, 2021).

The widespread adoption of digitalization, automation, and robotics technologies is increasing uncertainties regarding the future of employment. According to the World Economic Forum's (WEF) 2025 Jobs of Tomorrow report, technology will be the biggest driving force behind the transformation of labor markets in the coming years. This change is taking shape through four fundamental technological areas: artificial intelligence (AI), robotics and autonomous systems (physical AI), energy technologies, and network and sensing technologies. The report predicts that these technologies will transform seven key occupational groups representing the world's largest labor pools (agriculture, manufacturing, construction, wholesale and retail trade, transportation and logistics, business and management, and healthcare). This technological integration has the potential to create higher quality and better-paying job opportunities by replacing low-value and repetitive tasks with roles that require higher efficiency and expertise. However, to ensure that this transformation provides inclusive benefits on a global scale, it is critical to support the dissemination of technology, set strategic workforce goals, and equip employees with the competencies to manage these new systems (WEF, 2025).

In this context, digitalization and Industry 4.0 technologies are fundamentally transforming the structure of production processes and the competencies expected from the workforce. In particular, gray-collar workers who possess both technical knowledge and digital skills stand out as a strategic workforce group that bridges production processes and digital systems. Therefore, the ability of businesses to maintain their competitive edge during the

digital transformation process depends not only on the development of technological infrastructure but also on strengthening the competencies of gray-collar workers with hybrid skills who can manage this transformation.

INDUSTRY 5.0 AND DIGITALIZATION

Although digital development has come to the forefront with the concept of Industry 4.0, digital transformation has become an increasingly important phenomenon in recent years. From a business perspective, digital transformation refers to a process that begins with the integration of rapidly evolving digital technologies into organizational processes to adapt to these technologies. New digital technologies significantly affect and reshape production processes. Smart factories that use robots, sensors, and autonomous systems, as well as "dark factories," where production is carried out based entirely on automation and lighting is not even necessary because of the lack of human labor, are concrete examples of this transformation. However, digital transformation does not only refer to a change in production processes; it also encompasses the development of new business models through the integration of technologies such as social media, artificial intelligence, and big data into business functions (Klein, 2020).

Digital transformation is not a linear process, and digital transformation, digitalization, is a multi-level process that reshapes strategic goals and intentions, organisational structure, and workforce capabilities at all levels of the business. Digital transformation affects all business activities, such as strategic decision-making, organizational structures, the adoption of technological advancements, business models, and innovation ecosystems. However, it has often been observed that digital transformation can fail in terms of the business's adaptation and the results expected from the adaptation process. McKinsey's 2022 Global Survey revealed that nine out of ten executives had initiated a major digital transformation since 2020, but only one in eight had achieved the intended results (Karabag et al., 2026).

In 2021, the Directorate-General for Research and Innovation of the European Commission called for a paradigm shift from Industry 4.0 (I4.0) to Industry 5.0 (I5.0), emphasizing that while the I4.0 era prioritized automation and efficiency through technological advancements, the new process of I5.0 should adopt a more human-centered approach, highlighting the necessity of sustainability and resilience. I5.0 aims to create a more balanced relationship between technology and the workforce, in which advanced technological tools complement human creativity and expertise. This new industrial paradigm is forcing organizations to reassess their practices and structures to better align with human-centered innovation principles (Hein-Pensel, 2026).

Industry 5.0 redefines supporting new technologies as tools that primarily support human well-being and secondarily business efficiency in the value creation process. As proposed by the European Commission, Industry 5.0 places human centrality, sustainability, and ethical responsibility at the heart of industrial development. This paradigm redefines the relationship between humans and machines, shifting the focus from automation and efficiency to collaboration and well-being (Piccarozzi et al., 2026).

With the rapid proliferation of artificial intelligence applications in business management during technological transformation, radical changes have occurred in human life and business organizations through the integration of AI connections. In business, artificial intelligence contributes to factors such as cost and time savings, increased customer satisfaction, more accurate strategic forecasts, goal setting, and decision-making speed (Sağbaşı and Kılıncı, 2024). These developments have given rise to the fifth industrial revolution approach, which advocates for positioning technology as a tool that supports and enhances human labor rather than replacing it. From the perspective of Industry 5.0, it is anticipated that production systems in which humans and machines work together will become widespread, and the combination of smart technologies with human intelligence and creativity is expected to enhance process efficiency. Additionally, with the development of reliable autonomous systems during this period, a reduction in waste and costs in production processes is expected. The concept of a robot is evolving to refer not only to programmable machines that perform repetitive tasks but also to intelligent systems that can interact with humans in certain situations. The new generation of collaborative robots (cobots), which add a more human dimension to robotic manufacturing processes, are designed to work alongside humans and are developed to detect human presence in the work environment, taking into account safety and risk criteria (Nahavandi, 2019). At this point, the importance of gray-collar workers, who play a critical role in managing human-technology interaction, will further increase.

The Industry 5.0 approach focuses not only on technological integration but also on the restructuring of the workforce and socioeconomic development. Industry 5.0 transcends the technological emphasis of Industry 4.0 by combining human-centric strategies such as intuition, emotional intelligence, and creativity with advanced solutions, thereby promoting enhanced resilience and innovation under rapidly changing conditions. It enables businesses to identify and capitalize on opportunities and respond to complex and evolving challenges, thereby

ensuring alignment with dynamic capabilities. Unlike Industry 4.0, which prioritizes operational efficiency and process optimization, Industry 5.0 aims to create an inclusive, resilient, and sustainable network by emphasizing the relationship between human skills, intuition, emotional intelligence, and advanced solutions (Mohammed et al., 2025). In this context, grey-collar workers can be considered strategic resources for enhancing organizational flexibility because of their hybrid competencies that combine technical expertise with cognitive coordination.

Current studies on Industry 5.0 focus on the integration of smart systems, the Internet of Things (IoT), and artificial intelligence (AI) technologies, highlighting the need for workforce retraining, the integration of digital competencies, and the adaptation of socioeconomic structures to support a green industrial revolution in terms of workforce transformation and skill development. In particular, in a comprehensive transformation process, the role of the workforce in ensuring a fair transition is becoming increasingly critical, encompassing workforce skills, socioeconomic structures, and industrial processes. The rise of Industry 5.0 offers opportunities to bridge the skills gap by providing the necessary tools for workforce skill development, lifelong learning, and socioeconomic advancement. However, the success of this transition depends on how well industries can leverage these technologies to prepare the workforce for the challenges of the rapidly evolving energy landscape. The integration of smart grids, energy storage solutions, and advanced manufacturing processes into the energy sector requires a fundamental rethinking of job roles and skills, making workforce transformation sustainable (Sharma et al., 2025).

The process of digital transformation has also led to the questioning of traditional classifications in the labor market. For many years, the structure of labor defined through the distinction between blue-collar and white-collar workers has gained a complex and transitional appearance. The continuous proliferation of digitalization shapes the nature and organization of human labor in production; however, digital transformation can render some tasks unnecessary, change existing tasks, and/or introduce new tasks and the need for people to interact with technological systems, which may require different skills and ultimately create new demands on workers (Eriş et al., 2020).

Digitalization, by enabling the integration of smart resources (machines, workers), products, and processes within and beyond organizational boundaries, should expand the analysis unit to include the work of white-collar workers who perform supportive tasks such as job preparation, control, or decision-making. However, it focuses on enriching the potential of blue-collar workers who perform manual tasks in the production field (Waschull et al., 2022).

Digitalization has blurred the boundaries between production and management processes; in fact, blue-collar and white-collar jobs in factories are often deeply intertwined at the process level, creating significant interdependencies to understand the anticipated changes. A large portion of the literature on the predicted positive and negative effects of digital technologies on human labor describes a general enrichment scenario for blue-collar workers. In this scenario, blue-collar workers continue to be an integral part of the system, have full control over decisions, and are supported by technologies to increase the number of complex jobs that require higher skills and involve higher cognitive demands. As a positive impact, it provides solutions that help blue-collar workers realize their full potential in a wide range of jobs, enabling them to take on the roles of strategic decision-makers and flexible problem solvers. From a negative perspective, a quite different scenario is drawn, assuming that blue-collar workers' jobs are generally losing value. In this scenario, workers submit to the directives and control of machines and advanced artificial intelligence technologies (Waschull et al., 2022).

Digital transformation, along with the modernization of operational processes in technological integration, triggers the planned restructuring of business models, the integration of new resources for innovation, and cultural change processes within the organization. Additionally, this process encompasses a broad phenomenon that affects industries, markets, and societies. Consequently, such change processes have become a widely researched phenomenon in various fields due to the increased use and adoption of technology in individual, organizational, and societal domains (Mühlburger and Krumay, 2024).

Digital technology initially focused on the digitization of internal processes and functions, such as workflow automation and increasing operational efficiency. However, as digital technologies have advanced, their scope has expanded to include more strategic and customer-centric initiatives. Today, this transformation encompasses a holistic approach that integrates digital innovation into an organization's core strategy, reshaping operations, business models, and industries, thereby redefining the value of organizations. By incorporating a human-centered perspective and emphasizing the collaboration between humans and machines, this process further advances the need for organizations to remain resilient and responsive to rapid and unpredictable technological changes. It is essential that technological capabilities align with human values and needs. This alignment not only enhances efficiency but also fosters a culture that embraces continuous improvement and adaptability. Organizations that

invest in both new technologies and employee training and engagement to maintain a human-centered approach can enhance product innovation. Digital transformation processes are often complex and require significant changes in organizational processes, decision-making frameworks, and employee roles. Such changes encourage innovative approaches to collaboration and workflows. In conclusion, effective information management is crucial for developing the organizational capabilities needed to navigate digital transformation processes (Hein-Pensel, 2026). From this perspective, gray-collar workers are positioned strategically as implementers and transformative actors of digital transformation. Combining technical knowledge with analytical and coordination skills, gray-collar workers represent the interface where human-machine interaction materializes at the operational level. Therefore, in digital transformation, the development of digital competencies among gray-collar workers, increasing their participation, and integrating them into information management processes are crucial for the success of the process.

With the widespread adoption of automation during digital transformation, artificial intelligence, robotic technologies, and data-driven decision support systems have been increasingly used in production processes. These developments have enabled routine and standardized tasks to be largely carried out by machines. Thus, not only a quantitative change but also a significant transformation in the nature of work has emerged in labor processes. Industrial robots used in automation systems are defined as multipurpose machines that can be stationary or mobile, programmable on three or more axes, automatically controlled, and reprogrammable. The increasing prevalence of such industrial robots in production processes is leading to significant changes in the utilization of labor (Graetz and Michaels, 2015).

Typical applications of industrial robots are assembly, distribution, transportation, processing (e.g., cutting), and welding, which are common in the manufacturing industry; harvesting in the agricultural sector; and the inspection of equipment and structures, usually in power plants. Between 1993 and 2007, the average robot density in the 17 countries analyzed by Graetz and Michaels increased by more than 150%, and in countries where the intensity of using robotic systems increased, it was found that the sectors with the fastest growth in robot density contributed to value-added growth at a rate of approximately 3.5% per year, depending on increases in labor productivity and national trends. The same study shows that the increase in robot density may have led to a faster rise in the working hours and possibly wages of skilled workers, while the increase in working hours and wages of low-skilled workers may have been negatively affected by the rise in robot density. It is noteworthy that medium-skilled workers were also less negatively affected than low-skilled workers, and this result supports the findings in the literature that some technological changes have been detrimental to medium-skilled workers (Graetz and Michaels, 2015). In conclusion, the concentration of robots, by limiting the working hours and wage increases of gray-collar (medium-skilled) workers, affects them less negatively than low-skilled workers but more negatively than high-skilled workers, indicating that gray-collar workers are in a relatively vulnerable position during the technological transformation process.

Socioeconomic transformations that emerged with the process of globalization in Turkey have significantly affected the structure of labor markets. Especially since the 1970s, high unemployment rates observed in developed welfare states have led to unemployment becoming a structural problem. During this process, significant wage differences have emerged between highly skilled and low-or unskilled laborers. With the integration of technological developments into production processes, the production structure and business models have changed, resulting in the increasing prevalence of flexible working arrangements. Accelerated by globalization, this transformation has led to the division of the workforce into two main categories: core and peripheral labor. In this context, the core workforce refers to employees with higher job security and commitment to the business, whereas the peripheral workforce encompasses employees with more limited employment security. In contrast, technological advancements have increased the demand for skilled labor, creating new employment opportunities for highly skilled workers. The decrease in job opportunities for unskilled labor has led to an increase in unemployment rates, resulting in a process referred to as jobless growth (Koca, 2020). In this transformation process, gray-collar workers, positioned at the intersection of core and peripheral labor force differentiation, carrying both technical and cognitive competencies, can be positioned as strategic intermediary actors adapting to technological change in the Turkish labor market.

In organizational transformation processes brought about by digitalization, resistance to change is frequently observed. Resistance to change is fuelled by multifaceted factors, such as uncertainty, lack of trust, and attachment to past experiences (Karabal et al., 2013). In today's conditions, where information and communication technologies are rapidly developing under the influence of Society 5.0 and Industry 4.0, the ability to adapt to constantly changing environmental dynamics has become a critical necessity for organizations. Therefore, it is considered an unavoidable situation for businesses to recognize their digitalization processes and adapt to this transformation in terms of organizational sustainability. Digitalization, in addition to being a strategic tool that

enhances the effectiveness of organizational activities, also brings about the reorganization of existing work processes. In this process, human capital, which is considered a difficult-to-replicate organizational resource, emerges as an important element in adapting to transformation; however, it also presents a significant challenge for organizations, as they need to persuade their employees to embrace change (Yalçınıyğit, 2021).

Digitalization inevitably changes the designs of technical systems in job design and interacts with the design of social systems. While redesigning current production methods and related human labor, decisions must be made regarding the overall task structure, task organization, interaction with technology, and the skills and competencies that people should possess. The risks and opportunities arising for human labor are not limited to blue-collar workers but increasingly encompass the cognitive and higher-skilled areas of work for white-collar workers, such as production engineers, team leaders, quality controllers, and managers (Waschull et al., 2022).

In contrast, it implicitly assumes that blue-collar workers will gradually become white-collar workers because of job enrichment and increased capabilities related to advanced digital technologies on white-collar factory workers involved in decision-making, control, and planning. For example, operators will take on tasks initially considered engineering duties, such as process control or continuous improvement. This interaction between blue- and white-collar workers will create the possibility of redistributing activities within and between organizations (Waschull et al., 2022). When these two extreme scenarios are evaluated together, it is evident that digitalization has made the boundaries between blue- and white-collar workers increasingly permeable rather than strictly maintaining them. At this point, the profile of the gray-collar worker emerges: hybrid actors who possess both operational technical competencies and cognitive skills, such as decision-making, process improvement, and digital system management. Therefore, digital transformation not only transforms blue-collar workers but also lays the groundwork for the structural empowerment of gray-collar employees who occupy middle management positions, are proficient in technology, and take on strategic roles within organizations.

The Transformation of White-Collar Workers in the Context of Digitalization and Industry 5.0

The academic literature examining the transformation of gray-collar workers in the context of digitalization and Industry 5.0 focuses on both the definition and strategic importance of this group. The key studies, focal points, and conceptual advancements highlighted in the literature are summarized in Table 1.

Table 1: Changes in Workforce Structure and Collar Colours in the Process of Digital Transformation and Industry 5.0: Literature Review Table

Author(s)	Focus of the Study	Key Findings
Eriş, Özmen and Bayam (2020)	Alternative collar colors beyond the blue and white collar distinction	It is argued that the era of traditional blue- and white-collar workers has ended, and alternative colors and hybrid roles, such as gray-collar workers, have emerged in the business world.
Hutchings et al., (2009)	Perceptions of training and development for gray-collar workers	This study emphasizes that gray-collar workers need a combination of technical skills and managerial competencies, and that development strategies for this group are critical for organizational success.
Nahavandi (2019)	Evaluation of Industry 5.0 as a human-centered solution	Industry 5.0, unlike Industry 4.0, places humans at the center and envisions a structure in which robots and humans work in collaboration (suitable for gray-collar roles).
Waschull et al., (2022)	Design of blue-collar and white-collar jobs triggered by digitalization	This study analyzes how digitalization has fundamentally changed job design and how “color codes” continue to be a decisive factor in work restructuring.
Gamberini and Pluchino (2024)	The future of work and social sustainability within the framework of Industry 5.0.	This emphasizes that career paths and work methods are being reshaped with a focus on social sustainability and technology, and that this process necessitates employees to acquire new skills.
Sharma et al., (2025)	The role of Industry 5.0 in the workforce and socioeconomic development	In the transition to sustainable energy, Industry 5.0 can trigger socioeconomic development by equipping the workforce with new competencies.
Piccarozzi, Caboni and Bruni (2026)	Prosperity, managerial behaviors, and technologies in Industry 5.0.	This study argues that enabling technologies (Industry 5.0 tools) must be used in conjunction with specific managerial practices to enhance employee prosperity.
Akarsu (2025)	Dynamics of digital flexibility and transformation of working practices in Turkey	It examines how digitalization has made working methods more flexible and analyses the dynamics of this transformation in the Turkish context.

Aydemir (2018)	Effects of Industry 4.0 on the Turkish Economy	This study evaluates the impact of technological transformation on the economic structure and Turkey's capacity to adapt to this process.
Benk (2021)	New areas of employment and unemployment in the information age and digitalization	This emphasizes that while digitalization eliminates some traditional job sectors, it creates hybrid employment areas that require new skills.
Çımrın et al., (2023)	A sociological analysis of being a blue-collar worker in Turkey	This study of the current situation of blue-collar workers lays the groundwork for understanding the impact of technological changes on this class.
Dulay Yangın (2020)	Effects of Industry 4.0 and digital platforms on labor law	This study discusses how digitalization is changing legal relationships and the need for a legal infrastructure suitable for new working models.
Ersöz and Özmen (2020)	Effects of information technologies on employees	This study examines the direct effects of digital tools on employees' work methods and psychological processes.
Gökalp et al., (2019)	Efficient employment management under the influence of digital transformation.	This study proposes a concrete roadmap for managing the workforce in the digitalization process for institutions.
Graetz and Michaels (2015)	Impact of robots on productivity and employment in the workplace	This study demonstrates with empirical data that the use of robots increases efficiency but reduces the working hours of low-skilled labor.
Heinrich (2018)	Impact of Industry 4.0 on employment and skill requirements	This highlights the importance of new skill sets (technical and digital competencies) suitable for future market needs.
Klein (2020)	Factors triggering digital transformation in businesses	This study analyzes not only the technological but also the managerial and organizational dimensions of the digitalization process.
Mohammed et al., (2025)	Title: Dynamic skills 5.0 and organizational resilience	This study examines the capacity of businesses and employees to adapt to changing conditions (resilience) within the context of Industry 5.0.
Bain and Price (1972)	Definition of a white-collar worker	By providing a historical and sociological definition of the concept of 'white-collar workers', it identifies the basis of class distinctions.
Birinci (2023)	Digitalization in social services management	This study examines how digital tools optimize service management processes and changes in professional roles.
Erdayı (2012)	Definition of white-collar workers	This study discusses the changing boundaries and definitions of white-collar workers in the modern labor market.
Ertürk (2020)	Green-collar workers and HR management.	Evaluates the importance of the sustainability-focused "green collar" concept in human resource processes.
Hein-Pensel (2026)	Corporate identity and digital transformation (15.0).	This study addresses the transformative impact of digital transformation on corporate identity in the process of Industry 5.0.
Jeschke (2022)	Security Paradoxes and Management.	This study examines how managers balance the pressure to improve productivity and safety standards.
Karabal (2018)	Resistance to change.	It analyzes the resistance mechanisms exhibited by employees during organizational transformation processes.
Karabag et al., (2026)	Stages and strategies of digital transformation	This study examines digital transformation as a multi-stage process and its alignment with corporate strategy longitudinally.
Koca (2021)	Turkey's labor market and COVID-19	This study analyzes the effects of the pandemic on the labor market and the role of digitalization in this process.
Kruyen and Sowa (2023)	Blue-collar workers in the public sector.	This highlights the importance of blue-collar workers in the public sector, a group that is often overlooked in human resources research.
Küsbeci et. al. (2022)	Conceptual study of collar classification	This study summarizes the conceptual transformation that collar colors in the business world have undergone with digitalization.
Mühlburger and Krumay (2024)	A contextual conceptualization of digital transformation	It has been argued that digitalization should be evaluated in different contexts (context-sensitive) for each business.

Sağbaşı and Kılınç (2024)	Artificial intelligence in business management	This study analyzes the areas of application of artificial intelligence in managerial processes bibliometrically.
Saniuk et al., (2020)	Social expectations in Industry 4.0	Evaluate the impact of technological development on social expectations and market changes.
Sözen et al., (2014)	Comparison of perceptions between blue-collar and white-collar workers	This study empirically examines the differences in responses and perceptions of organizational events among different collar groups.
Yalçınıyğit (2021)	Digitalization and resistance to change	Analysis of institutional and individual resistance to technological innovations
Yiğit and Engin (2025)	Industry 5.0 and sustainability.	Examine the relationship between Industry 5.0 and sustainability using a bibliometric approach.

When the studies presented in the table are evaluated together, it is observed that gray-collar workers increasingly occupy a central position in the digital transformation process. Research focusing on the evolution of the collar concept reveals that the traditional blue- and white-collar distinction has begun to lose its explanatory power with the advent of digitalization (Eriş et al., 2020). In this context, gray-collar workers are defined as intermediate-level actors who possess technical expertise, coordination, and cognitive skills (Hutchings et al., 2009). Studies arguing that digitalization reshapes job design and creates hybrid roles by integrating production and management processes also support this transformation (Waschull et al., 2022).

The literature on automation and Industry 4.0 explains the impact of this transformation on the employment structure in a more concrete manner. It has been shown that while robot technologies reduce low-skilled jobs, they strengthen positions that require medium and high technical competencies (Graetz and Michaels, 2015). Similarly, it is emphasized that digitalization increases the demand for technical expertise and that routine jobs are at risk (Saniuk et al., 2020). It is stated that skills such as creative thinking, problem-solving, and digital literacy will become a priority for the workforce of the future (Heinrich, 2018). It is also stated that digital transformation has created a structural change in the competency sets of employees (Ersöz and Özmen, 2020). In this context, the digital economy highlights a hybrid workforce profile that combines technical knowledge with analytical capacity.

The perspective of Industry 5.0, on the other hand, shifts the discussion to a human-centered plane. Technology is stated to take on a complementary role instead of replacing humans (Nahavandi, 2019), and it is emphasized that employees with hybrid competencies gain strategic importance in the human-centered production model (Gamberini and Pluchino, 2024). It has also been demonstrated that digital transformation is a multistage process and that mid-level technical experts play a critical role at the implementation level (Karabag et al., 2026). It is also stated that in the digital age, organizational resilience is strengthened through employees who combine technical and cognitive competencies (Mohammed et al., 2025). However, it is observed that digitalization creates not only opportunities but also paradoxical tensions. The balance between the pressure for efficiency and safety standards is particularly critical for technical middle-level employees, and this situation can create a cognitive load (Jeschke, 2022). Overall, the literature shows that digital transformation is not just a technological advancement; it is a multidimensional transformation process that restructures the workforce and elevates gray-collar workers with hybrid competencies to a strategic position.

THE LABOR MARKET IN TURKEY AND THE POSITION OF WHITE-COLLAR WORKERS

Work life, which holds a central position in individuals' lives, has undergone significant transformation because of the effects of globalization and technological developments. The rapid development of technologies, such as the Internet of Things, cloud computing, augmented reality, and artificial intelligence, is reshaping not only technological infrastructure but also lifestyles and work patterns. The collection and analysis of data obtained from production processes are anticipated to lead to the emergence of more efficient and effective business models in the future. With the increasing prevalence of these technologies used by businesses today, it is believed that some professions may disappear, while new and different fields of work may emerge. In line with the requirements of the digital age, the knowledge, skills, and working methods of employees are also changing; in particular, the preference for individuals with high technological usage competence is becoming increasingly important (Ersöz and Özmen, 2020).

Many professions that rely on physical labor and muscle power are at risk of disappearing because robots can now perform them due to technological developments associated with digitalization. In particular, computer-based professions with a high likelihood of automation are expected to be more affected by digital transformation (Gökalp et al., 2019). In Turkey, this situation is leading to negative evaluations, especially for those working in the service sector. The ability of robots and artificial intelligence technologies to automatically perform many tasks has

created expectations that the demand for both blue-collar and white-collar workers may decrease (Aydemir, 2018). However, it is anticipated that new job fields will emerge through recruitment processes conducted via digital platforms. Additionally, it is stated that artificial intelligence technologies can be used to a certain extent in some professions, such as medicine, law, the judiciary, and teaching (Dulay Yangın, 2020).

The transformation in working life due to globalization and the impact of digital technologies is significantly changing the structure of the labor market in Turkey. The widespread adoption of next-generation digital technologies is paving the way for the development of data-driven, automation-based new business models in production, service, and management processes. In this process, it is expected that some professions will disappear, while new and more technology-intensive job fields will emerge. Jobs based on physical strength or with a high likelihood of automation are at risk; conversely, positions requiring digital skills are gaining importance (Ersöz and Özmen, 2020; Gökalp et al., 2019; Aydemir, 2018).

This transformation is reshaping the demand for labor in Turkey, highlighting a profile of employees with hybrid competencies beyond the traditional distinction between blue- and white-collar workers. Gray-collar workers who can use digital systems, perform data analysis, and manage the interaction between technology and humans occupy a critical position in this new structure. The possession of technical knowledge, coordination, and cognitive skills makes them mid-level specialists that automation cannot completely replace. Therefore, digital transformation in Turkey's labor market indicates a structural change that increases the risk of polarization while strengthening the strategic importance of gray-collar workers.

Studies conducted in the Turkish context show that digital transformation is leading to structural repositioning in the labor market. It is stated that especially technology investments are coming to the forefront, but policies aimed at improving the quality of the workforce remain relatively limited (Koca, 2021; Benk, 2021). However, the effective use of digital infrastructure depends on the presence of qualified mid-level employees in the field who will manage and adapt these systems. At this point, gray-collar workers, strategic implementers, and human-technology interfaces play a central role (Karabag et al., 2026; Mühlburger and Krumay, 2024).

However, the literature reveals that digital transformation not only creates opportunities but also generates new areas of risk, such as efficiency pressure, role tension, and the security paradox (Jeschke, 2022). If vocational education systems are not updated to include digital competencies and lifelong learning mechanisms are not strengthened, digitalization may deepen polarization in the labor market instead of empowering workers in grey-collar jobs (Waschull et al., 2022).

In conclusion, the table-based literature analysis reveals that gray-collar workers are a critical segment of the workforce in Turkey, positioned at the center of digital transformation, and possessing hybrid competencies that encompass both strategic opportunities and structural risks.

DISCUSSION

The evaluation of digitalization from employees' perspectives reveals significant opportunities. First, the possibility of remote work contributes to improving work-life balance. Flexible work organization models partially free employees from the constraints of time and space, allowing them to establish a more balanced structure between work and private life. Digital transformation also offers employees significant opportunities to acquire new skills and knowledge. Continuous learning and competency development processes facilitate individuals' adaptation to changing work environments. Automation, information technologies, and human-machine interfaces are also creating significant opportunities for career development for employees in high-value new job areas (Saniuk et al., 2020).

With the ongoing process of industrial digitalization, there have been significant increases in production activities based on information and automation technologies, and these developments have had various impacts on the employment structure. Research in this field shows that industrial digitalization leads to transformations in labor markets and working methods. The demand for low-skilled labor may decrease, whereas the need for qualified labor specialized in planning, control, and information technologies is expected to increase (Birinci, 2023).

Digital change and transformation are affecting individuals' lives and, in this context, are creating impacts on labor markets. Keeping up with the rapid transformation of digital technologies and adapting this situation to the business world has affected individuals' work environments and ways of doing business. Companies in almost every sector worldwide are utilizing digital technologies to maintain their competitive edge and ensure sustainability. In this process, institutions aim to enhance their competitive power and achieve a sustainable digital transformation by creating strategic infrastructures that support the digitalization process, restructuring business processes accordingly, initiating efforts to strengthen technological infrastructure, increasing employee productivity, and

making the work environment more flexible. Digitalization, in addition to developing skills, is transforming the nature of work and the structure of the labor market, directly affecting employees' lives (Akarsu, 2025).

The impact of digitalization on the workforce is addressed in the literature with two opposing visions. The enrichment scenario envisions a positive transformation in which blue-collar workers use technology as a support tool, taking on roles as strategic decision-makers and flexible problem solvers with increased cognitive demands. This approach parallels the concept of Operator 4.0, which aims to empower 'smart operators' with new skills. In contrast, the value-loss scenario paints a grim picture in which employees submit to AI directives and their roles are reduced to merely monitoring the system. This enrichment process assumes that blue-collar workers will gradually evolve into white-collar roles; this, in fact, lays the groundwork for the structural strengthening of the gray-collar worker profile, which encompasses the competencies of both classes (Waschull et al., 2022).

In Turkey, structural transformations, such as industrialization, globalization, and technological developments, have significantly triggered the emergence and forms of labor movements, giving a new dimension to the working class. Unions, strikes, and collective agreements have formed the main tools of these movements, and labor movements have often influenced political processes and social transformations. In Turkey, labor and worker movements have been shaped by the country's historical development and industrialization processes. The labor movements that began to emerge in the late Ottoman Empire became more visible over time, despite limited union rights and organizational opportunities. In the process extending from the Republican period to the present day, these movements have continued to develop around demands such as improved working conditions, wage justice, and the protection of social rights. Today, while unions play an important role in protecting workers' rights, they face various challenges regarding job security and working conditions. In particular, the pandemic period has led to greater importance being placed on issues of worker health and safety. In this context, labor movements in Turkey continue to evolve in response to changing economic and social conditions (Akbaş, 2026).

In modern Turkish history, the view that it is difficult to speak of an independent labor history is based not only on the definitions used in the literature but also on the developments that have occurred throughout the historical process. In studies conducted over a long period, the working class has been defined as wage-earning, predominantly male, blue-collar workers employed in factory-type production systems that emerged during the industrial revolution. However, with the political, social, economic, and cultural transformations that began in the 1990s and 2000s, the emergence of a new generation of researchers has led to a more comprehensive examination of the working class in historical studies and contributed to the concept becoming more visible in the literature (Eriş et al., 2020).

It is generally accepted that the concept of "collar," used to describe employees actively involved in working life, emerged with the changes in production and working conditions that arose after the First Industrial Revolution. For many years, employees in businesses have mostly been classified into two main groups: blue- and white-collar workers. However, over time, industrial revolutions and the diversification of job fields have led to the differentiation of employee classifications. During this process, some employee categories that were present in the literature but initially did not receive much attention became more visible, and in addition to the traditional blue and white-collar distinction, new classifications such as gold, gray, pink, and green-collar workers began to be used (Eriş et al., 2020).

The concept of gray-collar workers worldwide offers diversity that varies depending on the economic structures and technological maturity levels of countries. In Western countries, this term is generally used to describe experienced white-collar workers who remain in the workforce after retirement or part-time work. In advanced technology-focused economies like China, it refers to strategic technicians specializing in fields such as IT, software, and design. (Hutchings et al., 2009).

To summarize the key analytical axes presented by the reviewed studies on the transformation of gray-collar workers: The literature review indicates that gray-collar employees are positioned not only as technical practitioners but also as strategic actors in the transformation process. Industry 5.0, and the human-centered production approach, emphasize that technology is a complementary element rather than a replacement for humans; it reveals that blue-collar workers are interface employees who manage human-technology interaction, design processes at the implementation level, and ensure operational continuity (Nahavandi, 2019; Gamberini and Pluchino, 2024). In this context, gray-collar workers stand out as mid-level experts who bring a theoretical vision of digital transformation to life.

The literature on the skill economy and robotization shows that while digitalization reduces routine and low-skill jobs, it increases the demand for hybrid roles that combine technical and cognitive competencies (Graetz and Michaels, 2015; Hutchings, 2009; Saniuk, 2020). This situation makes gray-collar workers fundamental pillars that

ensure production efficiency, quality control, and technological adaptation. However, this strengthening also brings with it the need for continuous skill updates, retraining, and digital literacy (Heinrich, 2018; Ersöz and Özmen, 2020).

In the Turkish context, there are no direct studies representing gray-collar workers or other defined collar categories according to the labor statistics of the Turkish Statistical Institute (TÜİK). However, the International Labor Organization (ILO) – ISCO occupational classification is used in Turkey's labor force data by the Turkish Statistical Institute (TÜİK). When examining occupational classifications in Turkey, we can consider the intermediate technical workforce, consisting of technicians, craftsmen, and machine operators, as gray-collar workers in the literature (TÜİK, 2025).

When the studies discussed in this section are evaluated together, it is evident that digitalization and industrial transformation significantly change the structure of the labor market. The widespread adoption of digital technologies offers employees new opportunities such as flexible working, remote working, and continuous learning on one hand, while on the other hand, it transforms the nature of jobs and the required skill levels. In particular, production systems based on automation, data technologies, and human-machine interaction reduce the demand for low-skilled labor while increasing the need for a mid-level workforce with technical, cognitive, and digital skills. In this process, the distinction between blue-collar and white-collar workers is becoming increasingly inadequate, and employees with both technical knowledge and cognitive competencies are coming to the forefront in production processes. It is understood that the labor force structure in Turkey has also been affected by this transformation; according to TÜİK data, the intermediate technical workforce, consisting of technicians, craftsmen, and machine operators, holds a significant share of total employment. This situation indicates that during the digital transformation process, gray-collar workers have become a strategic workforce group that bridges technology and human labor in production processes.

CONCLUSION AND RECOMMENDATIONS

This study reveals that within the framework of digital transformation and Industry 5.0, the traditional distinction between blue-collar and white-collar workers is insufficient to explain contemporary production systems, and that gray-collar workers have taken on a strategic position. The labor processes that have evolved through industrial revolutions have made hybrid actors, who now possess technical, cognitive, and managerial skills, the "support pillars" of production.

Evaluations show that gray-collar workers hold an important position within production systems during digital transformation. First and foremost, gray-collar workers serve as a critical bridge between technical expertise on the production floor and strategic decision-making processes at the management level. With the acceleration of digitalization, it is observed that routine tasks are taken over by machines, while the demand for intermediate technical workforces with skills in problem-solving, data analysis, and managing human-technology interaction has increased. When evaluated in the context of Turkey, the number of people employed in the fourth quarter of 2025 was reported by TÜİK to be approximately 32.7 million. In terms of occupational groups, technicians, technologists, and auxiliary professionals constituted 10–12% of this number, while facility-machine operators and assemblers made up 12–14%. When the two groups are considered together, the share of the intermediate technical workforce, or "gray-collar" workers, in total employment reaches approximately 22–26% (TÜİK, 2025). This ratio indicates that employees who combine technical knowledge with practical skills (such as technicians, operators, and maintenance specialists) hold an important place in the labor market for production processes.

With all of this information, it is noteworthy that despite this strategic role, gray-collar workers often remain secondary in human resources policies and do not find a clear counterpart in career development and motivation systems. Additionally, the digital transformation process not only creates opportunities but also brings along new psychosocial risk areas, such as increased pressure for efficiency, cognitive load, and security paradoxes. This situation reveals that gray-collar workers are both critical actors in the transformation process and a workforce group facing new work-related risks.

Various policy and practice recommendations are being developed to strengthen the role of gray-collar workers in digital transformation. First, vocational education systems need to be updated to adapt to digital transformation. In this context, it is important to reorganize educational curricula to include digital competencies such as artificial intelligence, data analytics, and robotic systems, which will increase gray-collar workers' interaction with technology. In addition, businesses should develop more holistic approaches towards gray-collar workers in their human resources policies. The creation of career paths and mentorship programs that are integrated with white-collar systems, transparent, and promote competency development can strengthen the motivation and organizational commitment of this group of employees.

In line with the Industry 5.0 approach, positioning technology as a tool that supports employees' creativity and problem-solving capacity, instead of replacing human labor, is critical. In this context, it is recommended to promote the widespread use of technologies that strengthen human-machine collaboration, such as cobots. On the other hand, considering the risks brought by digitalization, such as stress, cognitive load, and burnout, it is necessary to restructure occupational health and safety policies to encompass their psychosocial dimensions. Finally, the development of national certification systems recognising the hybrid technical and cognitive skills of gray-collar workers through public and private sector collaboration will be an important step in strengthening the mobility and professional status of this group in the labor market.

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