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Thematic Section - Industry 5.0: Human-centric production management (Social systems for future manufacturing)

The evolution of work design models toward I5.0 Humancentrism and beyond

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Abstract

Paper aims: Production Engineering, as a knowledge field, was born with Frederick Taylor and his seminal analysis of work in industry. Over time, work design gradually changed, due to a complex set of factors. Nowadays, although work is at the center stage of societal concerns, work design modeling is understudied and undervalued, as if everything depended on technological advances only.

Originality: To assess the evolution of work design models, I created a framework based on five elements: Technology, Model of Person, Management System, Work Blueprint, and targeted Outcomes. It allows for a comparative analysis of the models and reveals their path dependence.

Research method: In this article, I perform a historical analysis. I use seminal works that established the foundations of Production Engineering and Operations Management, combined with those that polemicize and establish the state-of-the-art in work design.

Main findings. Using that framework, I highlight the key features of each work design model, disclose their path dependence to cope with increasing complexity, and discuss the options currently available to understand better the challenges associated with work design in the future.

Implications for theory and practice: Evolutionary analysis is valuable for research and teaching, whereas the analytical framework may help practice, organization and work design.

Keywords

Work design. Work organization. Sociotechnical work design. Organization design.

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Conflict of Interest

No conflict of interest whatsoever.

Ethical Statement

No ethical statement was required since the original intention of this development was to support students attending the course Work Organization in Industry, which the author taught for more than 40 years.

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INVITED PAPER

1. Introduction

In his latest book, *Nexus*, Yuval Harari (2024) states: "History is not the study of the past; it is the study of change". For Jones & Khanna (2006), retrieving the history of a knowledge field like Production Engineering and Operations Management is paramount for four reasons. First, historical change sheds light on conceptual issues; second, historical evidence prevents mislabeling certain phenomena as 'new'; third, history enables us to move beyond the often-recognized relevance of path dependence matters; and fourth, specific issues are inexplicable, except in the long historical run.

We are witnessing and involved in an extremely complex process in which new technologies boost social transformation. Changes are taking place in every aspect of human activity, especially at work. Some buzzwords include technological revolution, digital paradigm, cyber-physical systems, artificial intelligence, unmanned production systems, technological unemployment, growing inequality, socio-technical transformation, and humanization.

In this article, I present a personal view of work design history to support the analysis of current facts and speculate about future trends. It has different and contrasting qualities. It is ambitious, since it aims to address 'work', a subject that is part of everyone's life and carries a complexity greater than ever imagined. At the same time, it is humble because of its narrow focus and simplified perspectives. It is biased, because it seeks to dialogue with a specific group of scholars and practitioners - those concerned with work design in productive systems; and it is open, as it does not bring definite positions and recipes. Finally, it is not original, since there are inspiring studies like those by Boyer & Freyssenet (1995), Zilbovicius (1999), and Parker et al. (2017).

Work is not self-organized (unless someone or some instance suggests it), and seldom takes place spontaneously (as in an emergency). Because "organization" is used for many purposes and meanings, I adopted the term 'work design models' to address issues often understood as work organization. In companies, work design is carried out by some decision-making instance inspired by a model. It regards the specification of the content, methods, and interrelationships between jobs to achieve organizational and technological requirements and employees' societal and personal needs, subject to the prevailing ethical, legal, social, and cultural conditions.

Models intrinsically simplify complex phenomena. The usefulness of the 'model' idea may be challenged, since many arguments suggest that modeling industrial life is an intellectual operation with no connection to reality. However, modeling is what allows us to decipher complex situations and understand industrial change. For Boyer & Freyssenet (1995), an industrial model is new when it sets different goals from the existing ones, implements new technological devices and organizational routines, and introduces original management and social systems.

The literature presents work design models chronologically, from the Taylorist-Fordist model, which reigned unchallenged for more than 50 years until the Humancentric proposal emerged. To carry out a longitudinal analysis, I propose a framework comprising the following elements: technology, model of person, and management system, which are combined by some method to create a working blueprint. For each work design model, I recalled the authors who were critical for developing it and drew a picture showing the precedence or causality between the elements.

I lost an in-depth assessment, although I gained breadth by using such an approach. Thus, I presented a longitudinal portrait that allowed me to address the points previously made by Jones & Khanna (2006) and set the grounds for speculating on the future. The main outcomes are that not everything is new about work design, there is path dependence, and the 'old' models still apply to industrial and social transformation.

2. The basic elements of the analytical framework

From the early days, there have been two fundamental questions regarding work design: (a) what are the characteristics of the persons involved? and (b) what the characteristics of the devices that will be used are. In other words, work design always requires a socio-technical approach. We adopt the following framework (Figure 1) to better understand the evolution of work design models.

The above figure shows links between the elements but not arrows. Arrows suggesting precedence or cause-effects will be displayed for each specific model.

- **Technology.** It is usually considered the key element for work design despite ambiguous interpretations. Technology may be defined as "the application of scientific knowledge for practical purposes, especially in industry" (Oxford English Dictionary, 2024). Therefore, the main determinant of technological advancement is science. Some authors claim that human and social needs should drive technological progress, but this is a permanently ambiguous discussion (Johnson & Acemoglu, 2023; Rodrik & Sabel, 2019). Here, we consider technology development as an exogenous variable for the firm; however, since different technologies are always available, technology choice becomes intrinsically related to work design.

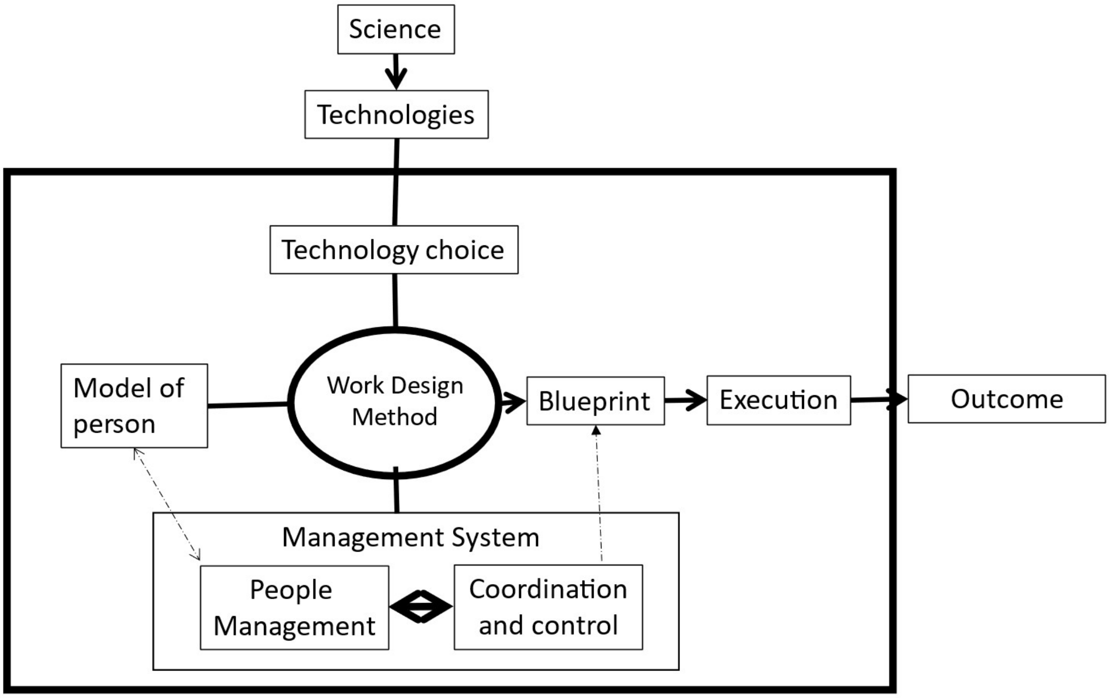

Figure 1. Framework.

- **Model of person.** These are the basic assumptions of the design process regarding the people involved in the work situation. McGregor's well-known "Theory X and Y" (McGregor, 1960) illustrates this point, which opposes Frederick Taylor's stereotypes, as presented in his "Principles of Scientific Management".
- **Work blueprint.** Blueprint is not a common term in work design, but I seek to distinguish the whole process of designing work from the information passed on to someone who will do the work. Therefore, I understand a blueprint as "something intended as a guide for making something else" (Vocabulary.com, 2024). For example, for Frederick Taylor, management must inform the worker what, when, and how something should be done. As we will see, that is not the case with other work design models; blueprints are different.
- Management system. I have already defined two essential elements (technology and model of person) and one targeted output (work blueprint). What remains to be designed is the management system: How will those pieces be implemented for the production system to achieve the desired outputs (productivity, efficiency, cost, etc.)? The management system must address coordination and control in a symbiotic manner with people management. People management includes activities directly related to tasks such as recruiting, selecting, training and developing, rewards, punishments, and layoffs, as well as supportive activities related to learning, communication, and transmitting ethical and social principles.

3. The past: deconstructing traditional work design models

3.1. Taylorism

Taylorism is paramount because it considers "time" a critical element of work design. Time is an unavoidable concern for the human race; everything revolves around the concept of time. Therefore, as time is inevitable, Taylor is indispensable. Although his 1911 book starts with a discussion on waste, it was the loss of time (and its optimization) that he sought to solve in his studies and interventions. Standard time is the key concept (Figure 2).

Taylor (1990) defined the principles of Scientific Administration in 1911: science instead of the rule of thumb; preparing detailed work methods, standard times, and rest periods; scientifically selecting, and then training and developing the best workers; and paying them according to their productivity, making the stimulus-response explicit.

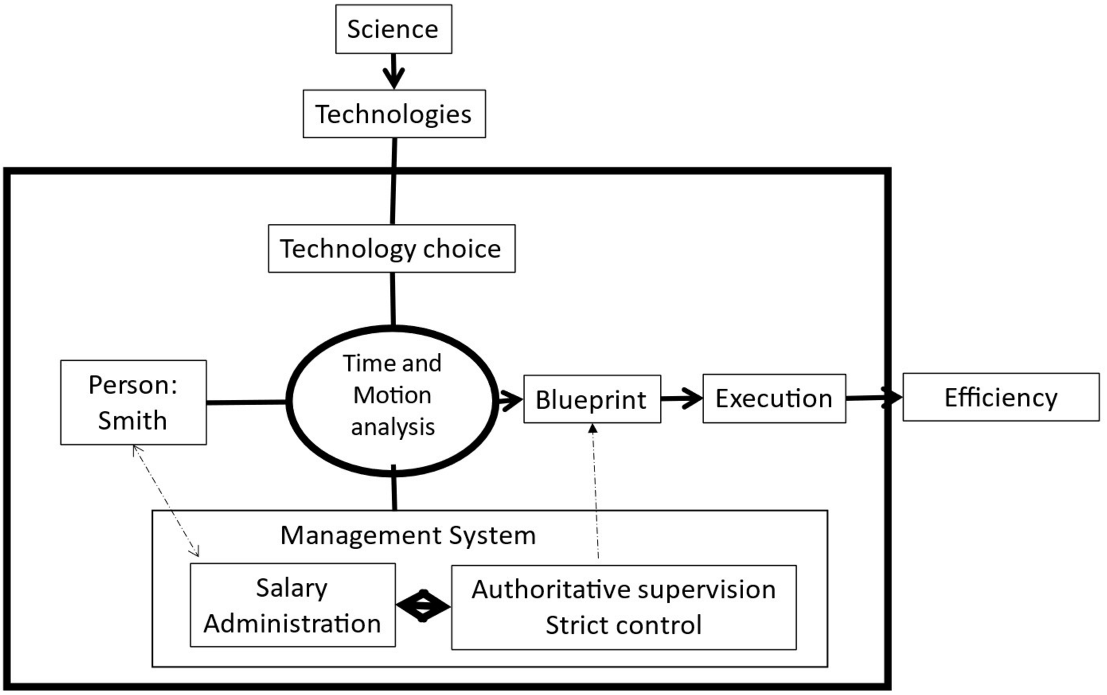

Figure 2. Taylorism.

- **Technology.** It is interesting to note that technology is ubiquitous in Taylor's analysis. He worked at a steel factory, but used specific experiments to draw his principles: shovel use, steel bar transportation, and rolling ball inspection. He even mentioned Gilbreth's experience with brick and mortar. To some extent, ubiquity is relevant because his principles are not linked to any specific technology, which makes them universal.
- **Models of person.** Taylor created different stereotypes. Perhaps the best known is Smith, "a Polish-born man who recently arrived in the US, runs from home to the plant in the morning, works all day carrying steel bars, then runs back home, where he still works on its construction. He is strong as a bull and has the mind of a donkey. For him, a dime is the same size as a wagon wheel". Taylor selected, trained, and guided Smith to increase productivity in steel bar transportation. Then, he trained other Smiths and reduced the labor force by 90 percent. In the case of rolling ball inspection, in order to to measure the reaction time for a person to visually identify defects on rolling balls in the palm of the hand, Taylor asked some academics to create a "Personal Coefficient". He chose only those with a low Personal Coefficient from hundreds of girls involved in that task, thus reducing headcount and increasing productivity.
- **Management system.** Taylor proposed fairness as the basis for the management–worker relationship. Standard time was used for training, evaluation, reward, and payment, which he defined as "a fair day's work for a fair day's pay". He made assumptions about human motivation and behavior. Money was the sole motivator for him, and people should be paid based on productivity, but salaries should have a ceiling. Taylor sought to innovate in supervision and control by proposing the replacement of one supervisor by a group of supervisors, each a specialist in one part of the production system. He also explored topics like ergonomics, psychology, and the social aspects of work, despite assuming he was not qualified to do so. Indeed, in the early 1900s, there was little formal knowledge of these dimensions.
- **Blueprint.** Managers should prepare detailed work methods, standard times, and rest periods. Workers should comply by obediently following instructions and collaborating by putting their best efforts into increasing productivity under strict supervision.

3.2. Fordism

After Taylorism, Fordism innovated by introducing technology as a determinant of work design. It is well known that Henry Ford conceived the assembly line after visiting a disassembling line in a slaughterhouse.

At Detroit's River Rouge, Ford built a factory where a whole production system was designed following the principles of time and movement, synchronized by the assembly line. While Taylor applied time and movement to specific situations, Ford did that on a much bigger scale, creating a paradigm that inspired management systems everywhere (Figure 3).

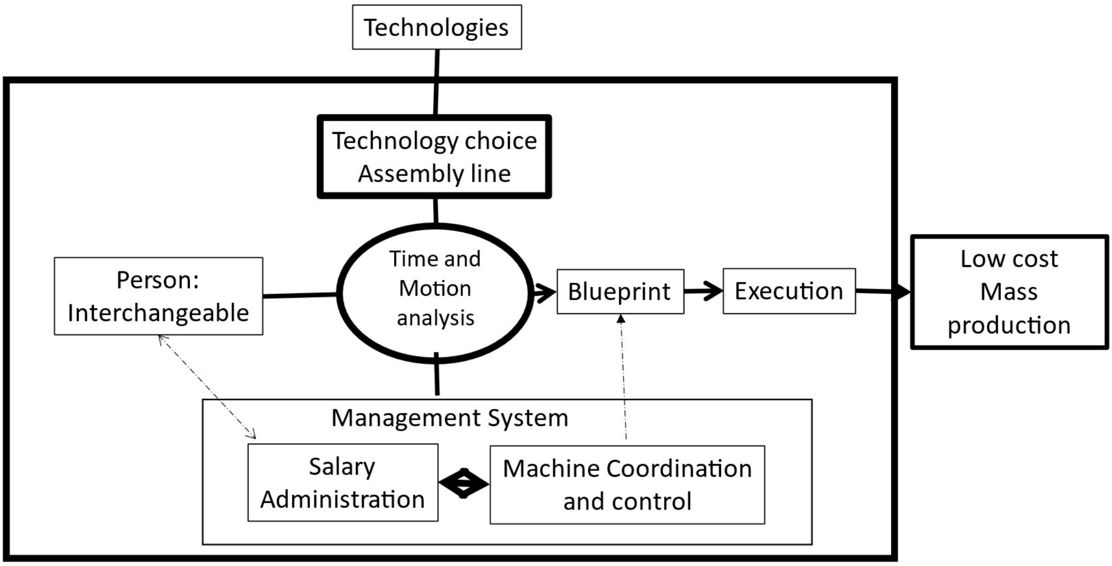

Figure 3. Fordism.

- **Technology.** The assembly line requires that product and process designs be done simultaneously. Then, the product is broken down into parts, so that each part is produced at one workstation. The total time for each workstation should be the same; it is usually measured in seconds, varying between 10 and 60 seconds, or a little more, depending on the speed of the conveyor belt. Work design demands that every task necessary for completing the output (product or part) be predefined and timed. The number of positions and the set of activities assigned to each position result from calculations of on-time distribution.
- **Model of person.** In Fordism, persons are considered simple-minded, interchangeable, and replaceable. Jobs were designed to require the minimum attributes, except for repetitive movements without any knowledge involved, and job design for disabled people is an example.
- **Management system.** Under Fordism conditions, the management system is simplified. The predefined tasks and the pace of the assembly line minimize the need for coordination and supervision. Recruitment has minimum requirements, and training is light and fast because tasks are rudimentary. That system was designed to cope with labor turnover. However, when this became dysfunctional, Ford introduced a policy where salaries became independent of the work done: US$5.0/day for a 40-hour work week, claiming that he intended to allow all workers to buy a car.
- **Blueprint.** The work blueprint was directly and uniquely related to the position in the assembly line. However, Ford systematically fought non-complying behavior, such as conversations, personal relationships, and even the exchange of job positions.

3.3. The human relations school and job enrichment

In the late 1920s, Hawthorne's Western Electric plant started experiments focused on productivity growth, following Taylor-Ford's assumptions. Due to the unexpected outcomes, Harvard University scholars and Mayo Clinic physicians were called to analyze them. The outcomes led to a different Model of Person and the creation of the Human Relations School for Work Design (Figure 4).

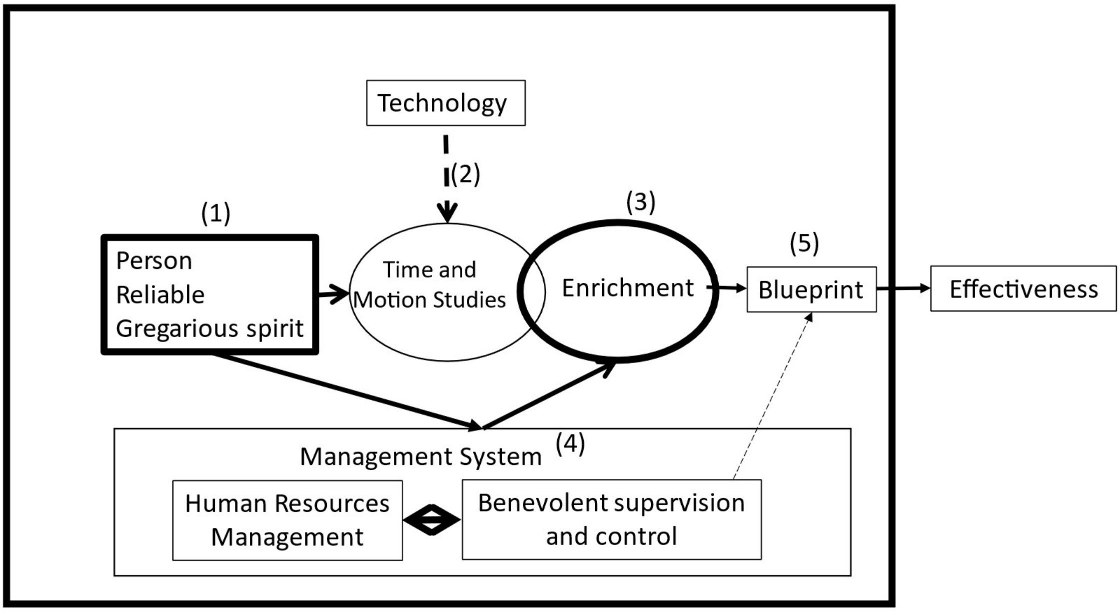

Figure 4. Human Relations Model.

- **Model of person.** The outcomes of the Hawthorne experiments (Mayo, 1933) showed that rather than considering workers as simple-minded, interchangeable, and solely motivated by money, work design should start from the following assumptions: (i) motivations other than money should be considered, increasing workers' satisfaction, leading to higher productivity; (ii) workers' interaction spontaneously creates groups, to which they are more loyal than to their employers; these informal groups generate an informal organization that demands supervisory schemes capable of identifying and aligning interests.
- **Technology.** The Human Relations approach is somehow evasive regarding technology, but it is plausible to admit that technology determines the basic design, which should be enriched to better suit human demands. The interventions proposed (job rotation, horizontal and vertical job enlargement, job enrichment) aim to improve a given situation rather than create a new desirable workplace.
- **Management system.** Management's essential task is to create the conditions for people to achieve their personal aims, while focusing their efforts on the company's goals (McGregor, 1960). This requires a democratic and participative management system based on human and social values and involves decentralizing decisions and responsibilities, job enlargement to increase work relevance, consulting decisions, and self-assessment. It represented the transition from Personnel Administration, typical of Fordism, to Human Resources Management (Mahoney & Deckop, 1986). Supervisors were trained to better cope with workers' behavior.
- **Blueprint.** Work design was still configured on an individual basis, but workers could have a voice in that process. Hackman & Oldham (1976) proposed that tasks should have the following attributes: skill variety, task identity, task significance, autonomy, and feedback.

3.4. Volvism: Tavistock's socio-technical principles and the Volvo experience

After World War II, the British government decided to nationalize coal mines to increase productivity and output. New conveyor belt technology replaced the traditional craftsmanship for extracting coal. The work was redesigned with the conveyor belts using a Taylor-Ford approach. However, the outcome was the opposite of expected: productivity and output decreased, and a surge of conflicts and psychological problems arose.

Researchers from the Tavistock Institute of Human Relations were called into that situation. After a careful investigation, they proposed keeping the conveyor belt, but instead of the minute work division characteristic of the Taylor-Ford approach, the group of people that made up a shift (around 40 persons) would become semi-autonomous: they were allowed to organize work according to their own preferences, as long as they achieved the previously defined production goals. The results were positive, both in the economic and social/psychological aspects.

Two lessons emerged from that experience. First, on practical grounds, the awareness that work designed around semi-autonomous groups was a feasible and efficient option. Second, on conceptual grounds, the notion that, for the same technology, different work designs were possible. The proposition then became the joint optimization of technical and social systems. In other words, it was explicitly recognized that no pre-conceived work design was optimal, and the search for an ideal one depended on the dynamics between technical and social systems. Action Research was proposed as the method to reach joint optimization, together with a set of practical recommendations (Cherns, 1976; Pasmore et al., 2018).

The socio-technical approach was paramount for Volvo's Kalmar experience. In the early 1970s, Volvo managers observed that Swedish participation in production operations was decreasing and started to think about what could be done to reverse it. They applied sociotechnical principles to that project, which became a significant demonstration effect (Figure 5).

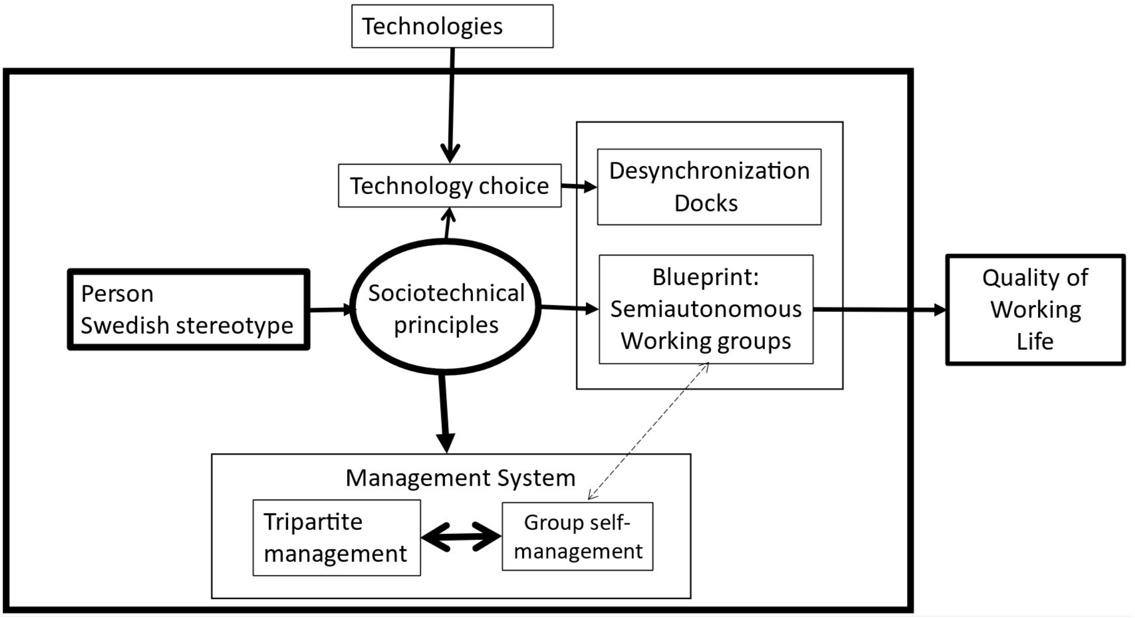

Figure 5. Volvism and semi-autonomous working groups.

- **Model of person.** The model assumes that Swedish are well educated, respect integrity and mutual trust, and value work-life balance. Likewise, Swedish social democracy provides very supportive institutions.
- **Technology.** The company created a steering group that included Volvo management, union representatives, and operational workers, who designed a new plant (the Kalmar plant) where Ford's assembly lines were reconceived, desynchronizing tasks and layouts, and introducing workstations/docks and semi-autonomous working groups. That required new methods and techniques for production planning and programming, settings, and internal logistics.
- **Management System.** The management system followed sociotechnical principles. A tripartite committee took responsibility for people management, respecting the premises for autonomy, consultation, and participation under negotiated conditions. The same token was valid for coordination/control since the semi-autonomous working groups were made responsible for production flow and output.
- **Blueprint.** The group is assigned a target (e.g., assembling a certain number of units of a given product in a certain period), and it has the autonomy to organize its activities as long as the target is achieved.

3.5. Toyotism: the Japanese production model

After visiting the United States in 1933, Toyota's CEO Sakichi Toyoda was fascinated by Ford Motor Co. and set up the automobile department. Different projects were developed but with little success. During the war, the

Japanese government required the company to produce trucks instead. After the war ended, car production was resumed, but experience and knowledge were limited.

However, chance intervened. Toyota's precarious financial situation forced it to ask banks for support. They agreed but required a massive layoff. The CEO took the blame for the situation and accepted the resignation, provided that all employees were ensured lifelong employment, the opposite of what Ford implemented.

Taiichi Ohno, an engineer, was chosen to lead the upgrading of the production system. Also fascinated by Ford, he began to implement the Taylor-Ford model. The difference was that workers had long-life employment; they could not be fired and replaced, as in the US. Hence, he made a deal with workers: he would design workplaces according to the Taylor-Ford method, but operators were expected to propose improvements. That highly successful initiative is at the root of Toyotism and the Japanese Production Model.

With Ohno, the logic of work design took a turn. Although the production technology remained unchanged - the conveyor belt was kept intact - unlike Taylorism, where managers set all the parameters of a given workplace, in Toyotism, managers are expected to develop methods and tools to teach workers to become decision-makers in production operations. Unlike the purely technical approach to automation adopted in Western companies, Ohno introduced the concept of autonomation, or automation with a human touch, which means using advanced technologies to increase human intelligence (Ohno, 1988).

Toyotism and the Japanese Production Model have a solid cultural root. They were born and nurtured in a reconstruction project to retrieve the nation's pride and sovereignty through strong collectivism and cooperation. Institutions and associations, such as JUSE and JPA, played crucial roles. Although Toyota was the root, the Japanese Production Model was a collective development (Figure 6).

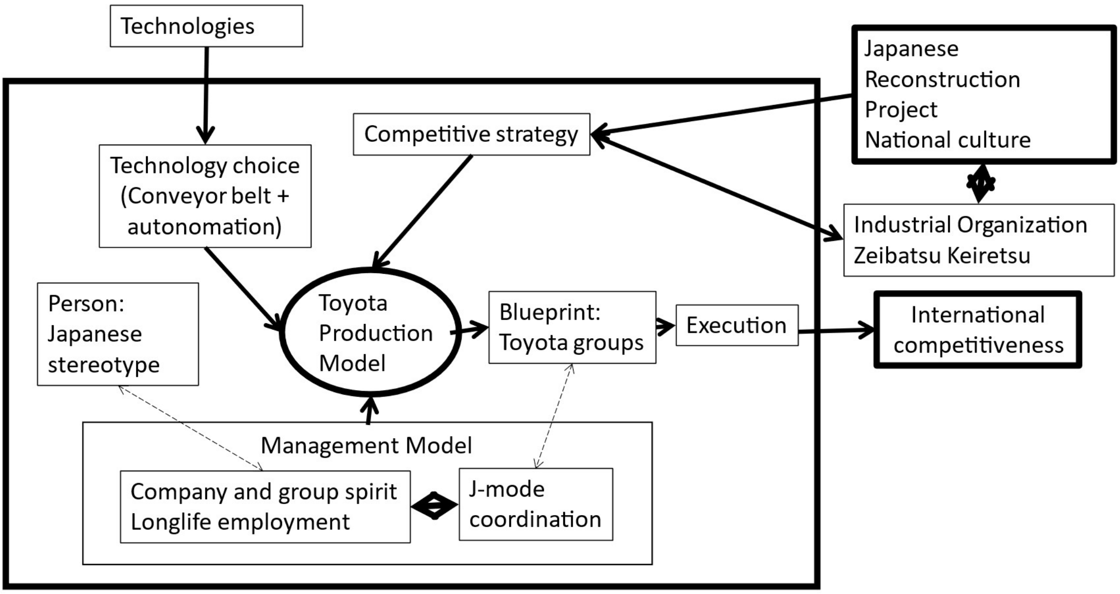

Figure 6. Toyotism and the Japanese Production Model.

- **Technology**. Rather than building new factories with different production layouts, as did Volvo, or using new technologies to automate or robotize work, like GE or FIAT, Toyota used information technologies to create mechanisms and devices that provided information; in a certain way, it structured production work at both individual and group levels, an approach that was called 'autonomation or Jidoka'. It meant implementing low-cost automation and empowering every worker to intervene in production tasks, at the first sign of an abnormal condition. Visual displays, like Andon, innovated to inform workers about flow problems and plant performance in real-time. In addition, the methods prepared for workers' participation, like Quality Circles, Kanban, and Suggestion Boxes, enabled passing on their knowledge and experience on behalf of the company, a process that was later systematized by Nonaka & Takeuchi (1995) in the book "The knowledge-creating company: How Japanese companies create the dynamics of innovation".

- **Model of person.** Toyotism was developed from an explicit characterization of the Japanese worker. First comes the issue of culture, which has two pillars: mutual respect and groupism/collectivism. However, the involvement of local workers in the operation of the Japanese Production System (Toyotism) was not free from resistance, requiring long-term motivational processes (Kondo, 1989).
- **Management systems** Unlike the Volvo experience, there was no steering group because unionism in Japan is peculiar, based on enterprise unions. From the point of people development, collective practices play a key role, and the particular internal hierarchy potentializes that due to lifelong employment, mutual training, and a labor relations system. Symbiotically, coordination is essentially horizontal, unlike Western companies' vertical type. The highest level of planning is just a comprehensive framework based on which the operating units structure their activities in an integrated way, relying essentially on current information from the work context. The horizontal coordination process creates learning dynamics much faster and stronger at the production process level, resulting in rapid and flexible response standards.
- **Work blueprint.** Each worker is an integral part of the production system. Its role involves direct action in production activities and assessment and improvements in a very methodical way and controlled environment. Therefore, to achieve targets, the worker exerts self-control and self-planning, interacting with people who have known for a long time.

3.6. Lean hybridization and lean-agile manufacturing.

The success of Japanese firms, like Sony and Panasonic, in addition to Toyota, all of them challenging the hegemony of Western companies, raised the question: can the Japanese Production Model be transferred to other countries with different cultures and institutions? Two lines of research, one focusing on the subsidiaries of Japanese companies and the other on Western, non-Japanese, firms were established. Japanese subsidiaries, like Toyota's NUMMI plant in California and Toyota plant in Kentucky, a non-unionized USA state, became showcases. Although plant architecture and hardware mirrored the parent company, and Toyota had transferred its systems and routines, the subsidiaries implemented functional equivalents and developed a proper management technology (Mishina, 1998).

On the other hand, Western companies struggled to accept and decipher the Japanese Production Model [JPS]. The gamechanger was MIT's book "The machine that changed the world: the story of lean production – Toyota's secret weapon", by Womack et al. (1990). While all previous analyses of JPS emphasized the strong cultural roots, that book was able to parameterize it, suggesting an approach – Lean Manufacturing - regardless of cultural factors. Due to its universal application, it was compared to Taylor's "Principles of Scientific Management". The initial concept of Lean Manufacturing was then extended to Lean Management, and finally to Lean Thinking, but changes were gradual.

Contrarily, a group of European scholars disagreed that Lean could be universal, and proposed the concept of hybridization, meaning that any work design model in one national space was only partially reproducible in another space; acculturation to the host country was mandatory (Boyer et al., 1998). Lean should be modified to cope with firms' contextual challenges. In principle, context was related to country's culture and institutions, but at the beginning of the 20th century, the global situation started to change significantly, so context became much more complex, being described as VUCA (Volatile, Uncertain, Complex, and Ambiguous). That led companies to rethink lean, introducing agile manufacturing, or hybrid lean-agile, relying on the increasing availability of digital devices, as shown in Figure 7.

- **Technology.** For Western companies, one of the biggest problems in the 1980s automation was analogic machinery communication, which contrasted with the Japanese approach to coordination, which was based on human communication mainly. That problem was gradually mitigated with the emergence of digital technologies, the Internet included, which radically changed production coordination and control logic. The turbulence of the operational context required strategies for flexibility and resilience. Companies then started a period of experimentation where innovations in software and hardware required a novel type of work system. The Hybrid-Lean Model emphasizes flexible, empowered work teams within agile manufacturing. Teams are (i) multifunctional, combining the knowledge and skills necessary to meet customer needs; (ii) dynamic and fastly reshaped, giving the organization flexibility and enabling rapid reconfiguration; (iii) cooperative, both within and between companies, to enable intra and interfirm cooperation for enhancing competitiveness; and (iv) virtual, which allows the company to combine resources (people and information) as needed, in order to reach entrepreneurial goals (Salerno, 1999).
- **Model of person.** In agile management, teamwork is the key concept. Therefore, individual traces include team orientation, expertise, and communication skills. As team resilience generally refers to "managing pressure effectively across the team as a whole, that further strengthens the team's capacity to deal with future challenges in adversity" (Hartwig et al., 2020), "stress load" drawback is also part of the picture.

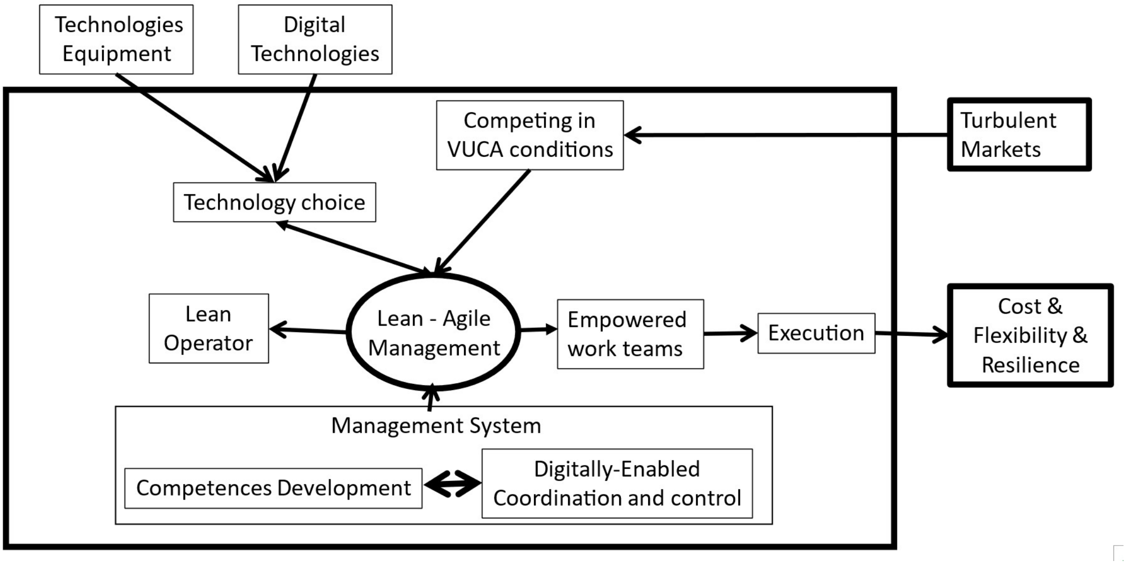

Figure 7. Hybridization – Lean Agile Manufacturing.

- **Management System.** The complexity of work roles in hybrid-agile management results in the main challenge for People Management, which is talent attraction and retention, as well as competence development, according to the challenges faced by the company. Notwithstanding, the increasing complexity of the dynamic relationships between execution, coordination and control, and People Management is being tackled in two ways: either by digitalization, as in Industry 4.0, or by sociotechnical approaches, as in Industry 5.0,

4. Contemporary work design: recycling for contextual adjustment

4.1. The new context: complexification of causal factors of work design

Regarding the framework previously applied, the current context presents a plethora of new factors that can affect modeling work design: governmental and institutional pressure, societal pressures, workers' reactions and movements, entrepreneurial initiatives, and technological change.

- **Institutions intervene in work issues.** Worries about unemployment and the lack of competitiveness of Western companies led governments to guide industrial development with an explicit concern for working conditions. One revealing case occurred in the US, where the Clinton Administration (1993-1997) implemented labor policies based on the assumption of three types of jobs: (i) routine jobs, which are not qualifiers, thus unimportant to the country, and should be exported as much as possible; (ii) service jobs, which are not qualifiers as well, but cannot be exported, and should be kept at home; and (iii) knowledge-based jobs, which are the most relevant, should be supported and encouraged as much as possible. Outsourcing routine jobs to foreign countries, especially emerging ones, led to the formation of GVCs – Global Value Chains.

The imbalances and potential consequences associated with the above situation led supranational institutions to become involved. In 1998, the ILO - International Labour Organization (1998) launched a manifesto for "Decent Work", defined as productive work for women and men in conditions of freedom, equity, security, and human dignity. ILO is the body that sets labor standards for working conditions in the majority of Western countries". However, the manifesto asked for spontaneous engagement, and its impact was limited. Later, the concept of decent work was retrieved through the United Nations' Sustainable Development Goals. Of the 17 SDGs, several keep an indirect relationship with work and working conditions. However, SDG number 8 aims "to promote inclusive and sustainable economic growth, and decent work for all, where workers have access to safe and secure working environments, and there is a reduction in precarious employment".

- **Workers' reactions and collective movements.** Regarding labor, movements were scattered and difficult to classify. Remote work (homework and autonomous work), already important in the past decades, was powered by the increasing pervasiveness of digital technologies. People started to seek self-determination in labor relations, which gave rise to the so-called 'gig economy', a free market system where organizations and independent workers engage in short-term work arrangements, usually supported by digital platforms across industries. Altman et al. (2021) developed a workforce ecosystem approach at MIT to address that situation, considering that work design should include internal and external employees.

The pandemic had an extraordinary impact on work and labor relations in general, brutally accelerating the adoption of remote work and forcing firms to rationalize their workforce while generating the phenomenon called "the great resignation". Employees in multiple sectors realized they were unhappy with their work-life balance, left their jobs, and were unwilling to resume them after the pandemic. This served as a wake-up call for employers to notice the low level of commitment they were nurturing in their companies.

- **The entrepreneurial agenda for sustainability and social problems.** The overall situation, characterized by visible inequality, growing dissatisfaction, and the active presence of governments, led to movements from management levels, like CSR – Corporate Social Responsibility - and wider causes like ESG – Environment, Sustainability, and Governance –, calling for more ethical behavior on the part of companies.
- **Digital transformation and employment.** The digital economy and technologies are the most important influencers on future work trends. Many worry about advanced technologies replacing human workers and decreasing the overall demand for labor. In 2013, Frey and Osborn estimated that 47% of existing jobs would be affected by digitalization. On the other hand, employment optimists rely on the assumption that, in the long run, the unemployment challenge will be overcome, due to the dynamics of industrial development. In MIT Technology Review, David Rotman (2024) observes that "people are worried that AI will take everyone's jobs, but there are no reasons for concern because we have been here before. Technological unemployment should be a myth because technology has created so many new industries and has expanded the market, thus creating more jobs overall". At the same time, there is a controversy regarding digital transformation's speed and rationale. MIT's Brynjolfsson & McAfee (2014) argue that technological change cuts jobs faster than it creates. Acemoglu & Restrepo (2017) called digital transformation "so-so" technologies because they replace workers and reduce salaries but do not generate productivity gains. On a micro level, research combining operations management and psychology shows that human decision-making in dynamic, complex, and fast-paced environments is often biased, resulting in suboptimal operational performance (Kessler & Arlinghaus, 2022).

I will try to draft contemporary challenges for work design, considering the two most visible trends: the technical, expressed by digital technologies and Industry 4.0, and the social, surrounded by Humancentric concern. It is essential to stress that there are no models like these yet, just developments toward one or the other or even to more hybrid types.

4.2. Industry 4.0, smart manufacturing, and the smart operator

The fourth industrial revolution is driven by digitization - the transformation of information into binary digital forms - and digitalization - the application of digital technologies (Rodrigues et al., 2016; Schwab, 2016). "Smart" is the metaphor for applying digital technologies in production systems. Figure 8 shows the logic for work design in Smart Manufacturing, starting from the assumption that the dynamics of technological innovation is the primary driver of strategic decision-making at the firm level. Technological determinism prevails, and companies continuously revise and adapt their strategies and business models to pervasive technological innovations, aiming to gain market share, sometimes articulated in business ecosystems (also enabled by digital technologies). The same trend is observed in configuring the Management System, where digitalization prevails.

The existing literature has identified three areas where digital technologies enable strategy and business model changes: i) servitization, the process of changing the strategic focus from producing to servicing, thus creating new product-service systems (Baines et al., 2020; Frank et al., 2019a); ii) new market-based relationships, leading to new cost structures (Brennan et al., 2015); and iii) *economic platforms* that enable firms to improve value capture in business, and *innovation ecosystems* (Gawer & Cusumano, 2014). From a strategic standpoint, digital technologies support coping with the increasing contextual complexity.

However, digitalization is a process, and most enterprises are still going digital. They are at different levels of digital maturity, understood as a firm's progress in its digital transformation path (Chanias & Hess, 2016). Therefore, the I4.0 model we present is speculative, since firms are still experimenting with digital technologies. In that context, the Model of Person is named Smart Operator.

- **Technology.** The most distinctive feature of I4.0 is the level of system integration. While Industry 3.0 was slow, with manual data handling and a hierarchical structure, in Industry 4.0, systems are integrated in real-time using automated data handling, cloud repositories, and a network structure (Adolphs & Epple, 2015). Several technologies

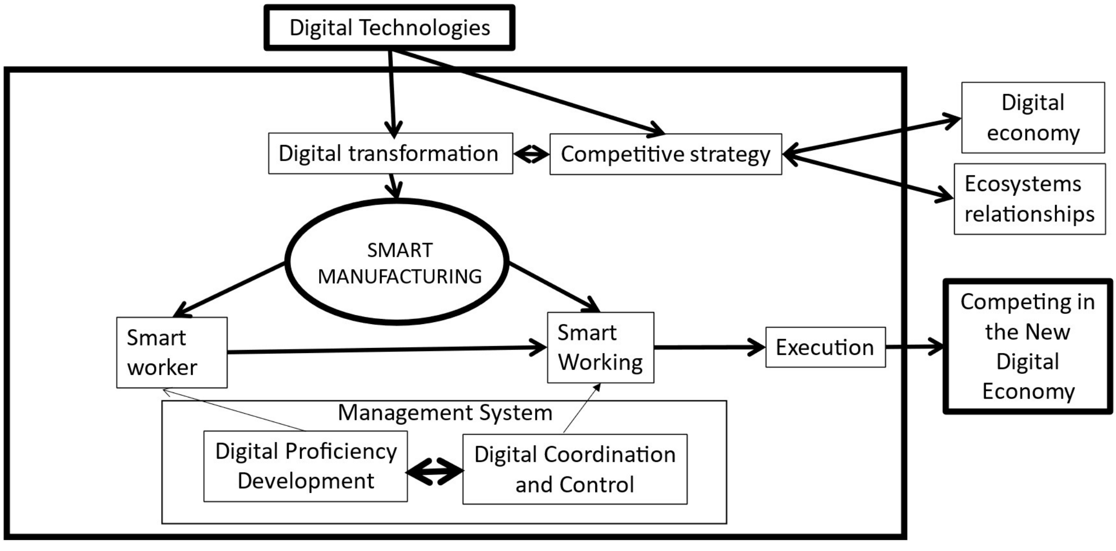

Figure 8. I4.0 – Smart Manufacturing and Working.

combine to enable Industry 4.0, like cheap sensors to collect data, the Internet of Things and Services to convey them, cloud computing to store a large amount of data, big data analysis, and artificial intelligence that supports automated simulation, forecasting, and decision-making. Together, they enable firms to build digital shadows or twins representing the physical systems. Digital and physical counterparts instantly update each other, forming a Cyber-Physical System (Kagermann et al., 2013; Liao et al., 2017).

- **Model of person.** The role of persons in digitalized production systems is still speculative and understudied. I hypothesize that the resilience demanded from individuals and teams in Agile Management to deal with contextual turbulence is multiplied by the uncertainties arising from the overwhelming rhythm of technological change. Consequently, complexity increases significantly, requiring new production and work design approaches, and digitalization and artificial intelligence are the preferred solutions. Notwithstanding, the literature offers three perspectives on the model of the person.

The first is the "smart operator" stereotype: smart manufacturing requires smart operators. This perspective resembles the Taylorist-Fordist model - people must have the skills to operate the technological system efficiently. The second perspective introduces the "digitally enabled worker," when some digital device enables workers' actions and performance. In the third perspective, workers play an auxiliary role in activities that are (incompletely) designed for machinery. The non-codifiable machine instructions are allocated to humans and, possibly, captured by some software. This third perspective characterizes machine learning guidance.

- **Model of Person 1: The smart worker.** The basic assumption is that digital technologies will require workers with higher-level competencies, to deal with the increased complexity of digitalized tasks in very dynamic working environments. Workers have to be highly flexible and develop adaptive capabilities, and this process will improve them as human beings. Therefore, smart manufacturing requires smart workers (Meindl et al., 2021).

For Ribeiro et al. (2024), workers in the I4.0 context have to manage new tasks and routines independently, find solutions, and solve problems in collaboration with technological resources, which demands engagement for self-learning and self-development. Skills include mathematics education, abstract thinking, communication skills associated with learning capabilities, performance metrics development, access to related technologies, and safety-related resources and procedures. The essential capacity is digital literacy, the ability to read, write, and communicate data in context. For Hecklau et al. (2016), the attributes of the smart operator can be multiple and diversified, as shown in Table 1.

The scope and complexity of the list led Romero et al. (2016) to ironically mention that "the Operator 4.0 in the 2020 factories resembles a jet fighter pilot, fitted with cognitive and physical enhancements, and connected globally through cyber-physical systems and the Internet of Things, Services and People".

Table 1. Desirable competencies of smart workers.

Technical competencies	Methodological competencies	Social competencies	Personal competencies
State-of-the-art knowledge	Entrepreneurial thinking	Intercultural skills	Flexibility
Technical skills	Creativity	Language skills	Ambiguity tolerance
Process understanding	Analytical skills	Communication skills	Motivation to learn
Media skills	Problem solving	Networking skills	Ability to work under pressure
Coding skills	Conflict solving	Ability to work in groups	Sustainability mindset
Understanding IT security	Decision making	Commitment and cooperation	Compliance
	Research skills	Ability to transfer knowledge	
	Efficiency orientation	Leadership skills	

Note. Source: Hecklau et al. (2016).

On the other hand, Hartmann & Shajek (2023) highlight three main drawbacks related to digital technologies: (i) immersion, the experience of direct interaction with a digitally created world, and the corresponding trend towards 'invisible', 'vanishing' human-computer interfaces; (ii) the use of Artificial Intelligence (AI) at the workplace, with its potential to replace and enhance human intelligence, and its effects on a growing lack of transparency of the inner structure and works of the technology itself; and (iii) digital labor platforms changing access to labor markets, contract and working conditions, and workers' rights and opportunities to associate and organize themselves.

- **Model of Person 2: The digitally-enabled worker.** Other authors consider that what best describes the smart worker is the man-machine interaction, like digital devices amplifying smart operators' capacities. Table 2, from Romero et al. (2016), illustrates that perspective by naming stereotypes creatively.

Table 2. Digitally-enabled smart operator.

Key enabling technologies	Typology
Operator + Exoskeleton =	Super-Strength Operator [physical interaction]
Operator + Augmented Reality =	Augmented Operator [cognitive interaction]
Operator + Virtual Reality =	Virtual Operator [cognitive interaction]
Operator + Wearable Tracker =	Healthy Operator [physical & cognitive interaction]
Operator + Intelligent Personal Assistant	Smarter Operator [cognitive interaction]
Operator + Collaborative Robot =	Collaborative Operator [physical interaction]
Operator + Social Networks =	Social Operator [cognitive interaction]
Operator + Big Data Analytics =	Analytical Operator [cognitive interaction]

Note. Source: Romero et al. (2016).

- **Model of Person 3: The machine learning operator.** Machine guidance occurs when a machine determines the information collection to perform a task, the solution path is predetermined, and decisions are made automatically. An example would be machine repair, where a person inserts diagnostic data manually, and another person does the repair according to specifications. Everything else lies within the machine. If other demanding tasks, which were previously under the responsibility of humans, are being automated, it can lead to de-skilling of workers.
- **Management system for I4.0** Digitalization involves the whole enterprise, not only the production system. Coordination and control of the production process is becoming fully digital, with digital twins being the stereotype for the new coordination patterns. Therefore, workers' control and the control of workers become ambiguous. Current digital management technology enables employees and managers to give and receive continuous feedback, thus tracking people's progress (Frank et al., 2019b). Depending on company decisions, digital control of workers may include emotions, heartbeat, and other personal attributes. The People Development function depends on the Model of Person adopted by the company. It may involve upskilling, reskilling, or deskilling. It is now supported by digital devices and software, which help managers identify better digital talents, monitor employee performance closely, anticipate training needs, and create repositories to implement lifelong learning systems.

4.3. Industry 5.0: The transition to a new humanism

The Industry 5.0 movement was born as a reaction to the technicism of the I4.0 proposal, as shown in Figure 9. The acronym I5.0 relates to a report issued by the European Union, recommending companies adopt

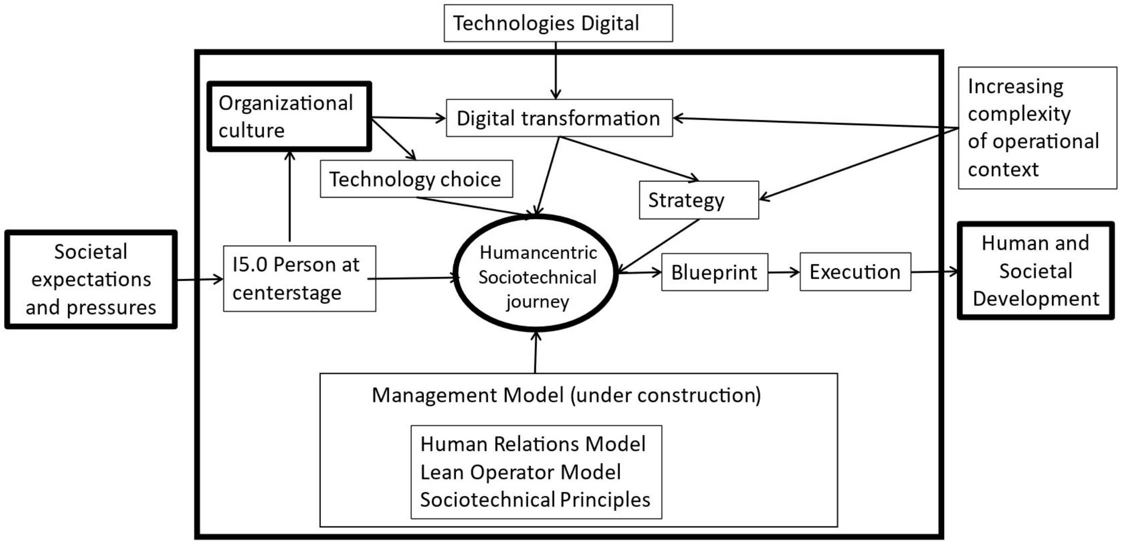

Figure 9. I5.0 Humancentrism.

management processes based on three pillars: sustainability, resilience, and humancentrism (Breque et al., 2021). It is a remastering of the UN Brundtland Report (Brundtland, 1987), which addressed economic, environmental, and social sustainability. According to the EU Report, Industry 5.0 complements and extends Industry 4.0, assuming that "digital technologies such as artificial intelligence (AI) or robotics allow radical workplace innovation, and optimizing human-machine interactions will capitalize on the added value human workers bring to the factory floor". It is a very appealing term due to the numerous by-products of Industry 4.0. However, Industry 5.0 is not an established research concept; it is a call for reconsideration, an ideology, rather than a formula for implementation (Reiman et al., 2021]; Xu et al., 2021).

- **Technology. Model of person. Management system.** Industry 5.0 proposes a symbiotic combination. It should target creating synergy and pairing humans and machines through human cognitive capabilities (creativity and knowledge) and interconnecting them with the workflows of intelligent systems. Despite recognizing the central role of digital technologies, it recommends that they should not be the only driver for technological choices.

Therefore, it seems licit to propose that, at firm level, the adoption and implementation of I5.0 must be driven by organizational culture through its different manifestations: values, rituals, policies, and practices (Schein, 1984). Humancentrism becomes a core value for enterprises, putting the human factor at the center of production design and prioritizing human development. Considering that contextual factors, namely, the turbulent environment and the overwhelming rhythm of technological change remain, the challenge is how to make it operational.

The cases reported on the adoption of humancentrism show a diversity of approaches, which may be justified by the novelty of the challenge and immaturity of practical experiences. The interesting part is how traditional Models of Person support its implementation, in practical terms.

- **Humancentrism and the Human Relations School.** There are reported cases where the implementation of I5.0 reminds us of the human relations concerns that emerged from the Hawthorne experiments a century ago. For example, the study by Parker & Knight (2023) keeps a strong similarity with the recommendations for Job Enrichment, suggesting five higher-order categories of work characteristics, including stimulating features (task variety, skill variety, information processing requirements, and problem-solving requirements), mastery work characteristics (job feedback, feedback from others, and role clarity), autonomous work characteristics (decision-making autonomy, timing autonomy, and method autonomy), relational work characteristics (social support, task significance, and beneficiary contact), and tolerable work characteristics (low levels of role overload, work–home conflict, and role conflict).
- **Humancentrism and Lean Management.** There are reported cases where the combination of Lean values, rituals, policies, and practices with digital technologies was used to implement humancentrism (Ericsson et al., 2024). The assumption is that the lean approach is a people-centered system that respects and employs human capabilities rigorously.

- **Socio-technical approach as a guide to humancentrism.** Other authors link the implementation of Industry 5.0 with the traits of the traditional Socio-technical Design (Sony & Naik, 2020). The assumption is that Industry 5.0 requires production systems to undergo a socio-technical evolution, that is, a paradigm shift in the operator's role as the central focus of manufacturing and production systems, through intelligent strategies and approaches supported by advanced information and communication technologies. Therefore, the resources provided by digital technologies and I4.0 are used together with socio-technical design principles.

In summary, humancentricity addresses the challenges associated with technological exclusion and unemployment but competes with the I4.0 movement: Which is the best solution for the company to deal with environmental complexity, purely technical or sociotechnical?

5. Discussion: insights from the historical analysis

The historical analysis of the evolution of work design based on the proposed framework allows for addressing the points raised by Jones & Khanna (2006). In particular, it helps understand how the context and some drivers have affected work design. Table 3 shows the changes in prevailing models in response to contextual factors and action drivers. Path dependence becomes visible.

Table 3. Context and drivers of work design evolution.

.Model	Context	Purpose/aim	Driver
Taylorism	Scientific Revolution	Efficiency/waste elimination	Frederick Taylor
Fordism	Rising mass markets	Cost reduction/scale	Henry Ford
Human Relations	Reaction to Taylor-Ford	Humanization of work	Academia Some US firms
Volvism	Swedish society	Revision of Fordiam targeting Quality of Working Life	Volvo Nordic countries
Toyotism	Country international competitiveness	Acculturation of Taylorism-Fordism	Government Japanese leaders
Lean - agile	VUCA type of markets	Hybridization and improvement of Lean	Leading Western companies
I4.0 Smart	Digital economy Geopolitical factors	Revision and adaptation of Taylorism	Bigtechs Leading companies
I5.0 Humancentric	Humanization Reaction to technical I4.0	Sociotechnical solutions	European governments Leading enterprises

Taylorism was born in the so-called Era of Scientific Discoveries, and introduced as Scientific Management. However, it seems correct to say that it was mainly the result of Frederick Taylor's obsession with waste. He focused on resource efficiency, which is, in principle, a cornerstone for every company.

Henry Ford devised a model for large-scale manufacturing firms, with low-cost products for mass markets. Technology played a special role in terms of coordination, which, to a certain extent, simplified the work design process.

The Human Relations Model was an unexpected outcome of industrial experimentation, presented as a counterpoint to the Taylor-Ford Model. It aimed to include workers' features and expectations as part of the work design process. Academics played a vital role in the diffusion of that model, and workers generally backed it.

Volvo developed its project to attract Swedish workers for production jobs. Using Tavistock's principles of socio-technical work design, the company followed local institutional commandments, organizing a task force composed of the tripod 'firms, unions, and government', to develop the new Kalmar plant based on semi-autonomous working groups. Toyotism also emphasizes groupism, but with a different rationale (Marx & Fleury, 1996).

Despite Toyota being the rising star of the Japanese industry and the paradigm of the Japanese Production Model, Toyotism is a collective creation in which Technology was kept as it was, the Model of the Person was redefined, the Management System acculturated, and workers' blueprints improved. This collective and long-term construction was supported by the Japanese government, aiming to restructure the country after World War II and reposition it in the global market. Hence, Toyotism, in its strict sense, is justified by the search for competitiveness of Japanese firms in international markets, which makes it somewhat different from the Volvo experience.

Lean manufacturing is another hybridization that has acculturated the Japanese Production Model to Western countries. In addition to companies' efforts to translate and adapt it to regain lost competitiveness, governments played an important role in fostering local firms' engagement in that movement. The USA Malcolm Bridge Award is a strong example.

Leading Western firms developed the lean-agile model to cope with the increasing volatility of institutions and markets.

14.0 Smart Manufacturing and 15.0 Humancentrism are proposals related to times of disruptive technological change that radically changed company-market relationships, combined with a tremendous shift in contextual conditions, as represented by natural disasters, pandemics, national rivalries, national interests, and wars. As happened in the 1970s and 1980s, when Taylorism-Fordism lost protagonism, two different reactions are being adopted by companies. The first, 14.0 Smart Manufacturing, is adopted by technology-driven companies based on the assumption that mastering and processing enormous volumes of information through digital technologies will bring efficient decision-making, survival, and competitive advantage. The second, 15.0 Humancentric, is sociotechnically driven. It relies on the assumption that only the joint optimization of the digital technical and social systems will bring coherence to the achievement of strategic aims.

Retrieving the historical perspective, in the 1970s and 1980s, technologically driven companies were unsuccessful, allegedly because technology was not fully developed then. Sociotechnically-driven companies, like the Swedish ones, made it better, but their work design model was not scalable. The winner was Lean, a hybridization of the Japanese Production Model, which was conceived under very special circumstances. For Tolliday et al. (1998), Japanese companies achieved a set of internally coherent and externally appropriate technical, organizational, managerial, and social devices and practices that enable them to effectively manage product-market and employee behavior uncertainties. There are similarities with the challenges currently faced by companies. Figure 10 shows the factors that currently influence work design according to our model.

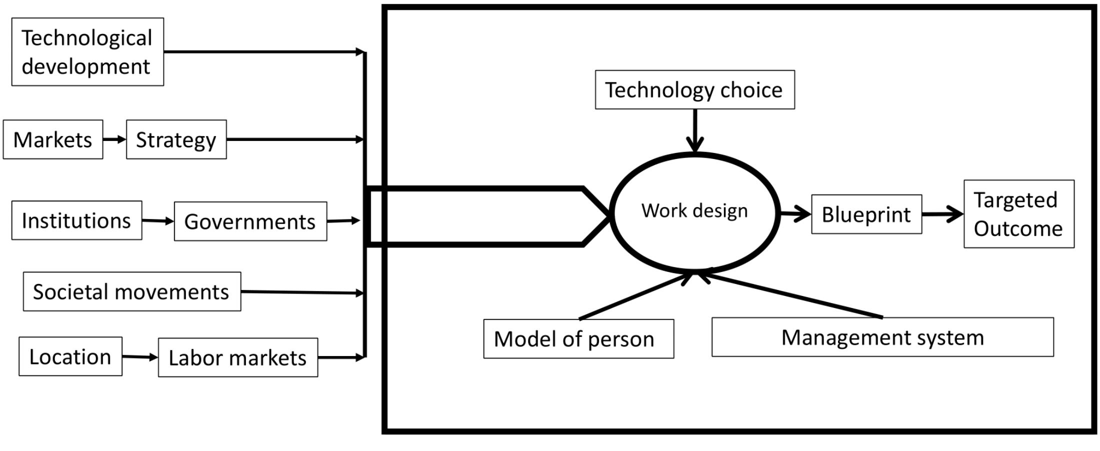

Figure 10. Work design process – elements and intervening factors.

An important point to stress is that, visibly, the framework is becoming more complex as time goes by, and complexity is expected to increase only in the near future due to contextual factors. In this vein, another framework, also named sociotechnical but adopting a macro-perspective, was proposed by Geels (2004) and may be combined, thus helping to create a more appropriate framework to tackle the challenge.

6. Final comments

A final question concerns the use of the framework to address and predict what will come next in terms of work design models. For that, we need a prediction of what the future will look like.

Considering the much-propagated perspective that digital technologies and AI will prevail, the elements Technology & Coordination & Blueprint & Execution, in the framework, will be automatized. The remaining elements: Model of Person and People Management will lose importance. Work will have an ancillary role only. The reversion of that movement seems complicated, even though reorienting global innovation in a more labor-friendly direction would benefit developing countries and advanced economies alike (Rodrik & Sabel, 2019).

There are other, less catastrophic scenarios, from which I chose the one devised by scholars linked to the original Tavistock Institute through Socio-technical Roundtables. Their vision was made public by Pasmore et al. (2019):

- First, digital technologies will change our definition of an organization. Instead of a free-standing, independent entity with well-defined membership, fixed location, and defined goals, organizations will engage in networks, connecting different bodies that vary in membership, location, and purpose over time.
- Second, as the technology to do the work will constantly evolve, the idea of joint-optimization will require continuous change and adjustment, rather than designing a social system around a fixed technology.
- Third, the application of advanced learning capabilities, enhanced by data analytics and artificial intelligence, will change how decisions are made and redistribute power from the center to the outskirts. The overall system should keep direction and congruence.
- Fourth, given the interconnection of organizational ecosystems, change will accelerate, requiring faster innovation, which will begin in different places simultaneously, from the outskirts to the center.
- Fifth, organizations will adopt multiple ways of working to accomplish their goals. The optimal organization of the future will comprise a variety of work systems, with different degrees of interaction between those involved. They can be 'designed or spontaneous', 'temporary or continuous'.

In that case, the framework proposed in this article should be revised due to the obsolescence of its foundational assumption: organization as an individual entity. Other approaches will have to be brought in, from which I highlight ecosystem management and work ecosystem management, two research streams that are gaining memento.

The Model of Person is absent from the scenario above. What are the attributes of persons working in such dynamic and volatile conditions? Or, looking from the other side, are there persons prepared for that situation? That is still open to investigation.

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Data availability

No research data was used.

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Afonso Fleury: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.