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Strategic Patterns in the Concept of Sustainable Development of Manufacturing Processes in the Field of Knowledge Management in Companies Operating in the Metal Industry in Poland

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Abstract: Sustainable development is an opportunity for modern enterprises to build unique market advantages, but it is always a kind of compromise between financial benefits and activities focused on environmental protection. It also requires companies to be able to acquire and process information, the sources of which are both internal and external, and to process it into effective knowledge. Quality management processes are an important element supporting knowledge management as a consequence of similar priorities. There are direct and indirect relationships between quality management, knowledge management and sustainable development. Related issues are an important element of modern research, but there are still some knowledge gaps that need to be filled. The authors, based on the literature analysis, concluded that there are no studies defining the relationship between quality management and knowledge management in the context of sustainable development relating to the Polish metal industry. Therefore, the objective of this study is to identify patterns of company activities in the area of knowledge management relating to the improvement of manufacturing processes in companies operating in the metal industry in Poland. At the same time, it was indicated which aspects of knowledge management are at the centre of management's concerns. The study was carried out using a survey questionnaire, with 1930 questionnaires collected from employees in 50 companies selected for the study. The study carried out discovered that in the various areas of the Japanese knowledge management model, companies distribute the emphasis differently, which manifests itself in the procedures and ways of operating. At the same time, there are significant differences between large and medium-sized enterprises, indicating that the scale of operation influences the perception of the importance of individual elements of the knowledge management system in the context of sustainable development.

Keywords: sustainable human resource management; knowledge management; quality management principles; metal sector

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1. Introduction

Today's market environment, characterised by a high level of volatility and increasing competition, forces modern market players to continuously improve and innovate. At the same time, it creates unprecedented opportunities for customers to gain knowledge about companies, compare their offers, and make choices based on a potentially large amount of data, which makes building and maintaining competitive advantages a significant problem for companies. In the era of sustainable development, companies are forced to create flexible strategies based, among others, on knowledge management or Total Quality Management [1,2]. These changes can be dictated by both internal and external factors. From an organisation's point of view, internal factors can flow from a simple calculus of activities. External factors, on the other hand, may flow from business and environmental

regulations, the level of competition and technology available on the market, as well as prevailing trends including corporate social responsibility. It is important to stress that each of the factors triggering the need for change, meaning, to some extent, the improvement of a particular area of activity, affects individual operators with varying degrees of force.

The rapid consumption of natural resources and dangerous emissions resulting from economic progress increase the burden on the climate and the environment every day [3]. This has increased external pressure on organizations to respond to the challenges of environmental degradation [4]. Enterprises that are able to cope with new challenges related to sustainable development have a better chance to increase their competitiveness nowadays [5,6]. At the same time—as shown in the results of research [7]—thanks to greater focus on aspects related to sustainable development, they have a chance, as a result of reducing production errors, to improve their economic stability. Although environmental sustainability is often seen as an organization's goal, the relationship between environmental protection and industrial strategy is usually seen as a compromise between environmentally friendly practices and financial gains [8].

The process of sustainable development is intrinsically complex and multifaceted, and covers a number of areas—often distant from each other—i.e., economic, technological or social areas. Economic sustainability as a process aims to continuously improve an organisation's key economic indicators and support its competitiveness in the market. Social sustainability is a programme to improve the quality of life for the population and future generations. Environmental sustainability focuses on the development of new production technologies, sustainable use of natural resources, and reduced environmental impact. While the majority of companies focus on achieving economic sustainability, it is important to note that social and environmental actions also have a positive impact on companies, although the effects may not be immediately noticeable. The complexity of the sustainability process means that companies often focus primarily on selected areas in their strategies, e.g., as a direct result of legislation, reporting requirements, etc. Simultaneously, their activities in other areas tend to be insufficient, leading to under-utilisation of their potential. For instance, actions to improve the quality of staff will increase costs, but improve the knowledge and skills of staff. The latter can suggest ways to improve, optimise work processes, and implement them. High industry pay and allocating a portion of profits to additional social activities for employees and staff development reinforce the company's reputation as a reliable, and caring employer, and affect brand awareness, which also tends to monetise.

Knowledge management processes are becoming a common practice and are nowadays considered an important element in the design and development of products in the context of sustainable development [9]. The success or failure of a company correlates with its ability to acquire and maintain knowledge [10]. Knowledge management processes allow enterprises to react quickly to changes [11] and to more effectively consolidate the introduced changes as well as modified or new processes [12]. Knowledge management is of key importance in the proper shaping of sustainable development [13]; it enables the transfer of useful information and intellectual property, and thus contributes to the sustainable functioning of the organization. Wu et al. [14] have shown that conducting business in accordance with the principles of sustainable development is based on knowledge management and on creating strong links for the exchange of knowledge between the organization and its environment. Acquiring knowledge from market partners and customers is of key importance for the sustainable development of enterprises [15]. Today, the scope of knowledge management is being extended by many enterprises with environmental aspects [16], and the resulting green knowledge management has become an important strategic resource [17,18]. There are a number of knowledge management methods and techniques in the literature and in business, the method based on the Japanese model being one of the better known. It assumes the dissemination of knowledge within the company through its transformation from individual implicit knowledge to group explicit knowledge. This makes it possible for a number of improvement measures to

be implemented in the company, including in the area of quality. Quality is crucial not only for the business outcome or the image of the company, but also for its impact on the environment and society.

As the research results show, quality management allows companies to build effective competitive advantages [19], including those consistent with sustainable development [20], and in conjunction with knowledge management, it allows the implementation of sustainable development in the supply chain [21]. The research results confirm the positive and significant impact of quality management on knowledge management processes [2]. At the same time, they indicate the existence of relationships between quality management and knowledge creation, as well as between knowledge management and sustainable development [12]. Modernly managed enterprises adopt knowledge, quality, and environmentally friendly practices as valuable strategies for creating a competitive advantage [22].

The relationship between the concept of sustainability and corporate management means ensuring the long-term successful functioning of the organisation, as well as working simultaneously towards economic, social, and environmental development. Sustainability is therefore one of the main challenges facing companies operating in a global environment. This problem is particularly relevant for companies operating in the metal industry, traditionally associated with negative environmental impacts.

From the point of view of the state of the art in the literature and applied business practices, it is important to answer questions on the following issues:

- The relationship between individual potential and employee commitment, and the quality level in enterprises in the context of sustainable development;
- The elements of organisational culture leading to the intensification of employee knowledge sharing processes;
- The activities of enterprises leading to the development of specific practices in the context of sustainable development.

Taking into account the research problems posed in this way, this article attempts to identify patterns of business activities in the area of knowledge management relating to the improvement of manufacturing processes in companies operating in the metal industry in Poland. The process of identifying these patterns was based on the assumptions of the Japanese knowledge management model and eight principles of quality management.

2. Literature Review and Hypotheses Development

The corporate sustainability management mechanism covers a series of planned activities to achieve the company's sustainability-related goals. Shaping the foundations of corporate sustainability management requires the formulation of strategies, objectives, functions, principles, and methods of corporate management, as well as the identification of the subject and object of management as part of the concept of corporate sustainability. The current conditions in which companies operate have an impact on the search for new management models with the primary aim of achieving a sustainable competitive advantage. As companies search for suitable business models for sustainable growth and development, they are simultaneously pursuing a strategy in line with the concept of sustainability.

Sustainability should be approached as a relatively new concept in management science. The clarification of the concept and meaning of sustainable development has evolved since the early 1990s. This is mainly due to the effect of new perspectives taking into account the assumptions of economic, ecological, and social objectives and methods of studying the phenomena taking place and the various possibilities of adapting them to strategic assumptions. The essence of the approach is based on a combination of two terms, sustainability and development, in order to resolve disputes between an economy based on sustainable growth and the preservation of a high-quality environment.

The level of sustainability is highly impacted by a company's resources. They consist of tangible and intangible elements that form a specific system. Tangible components of resources are physical resources such as buildings, equipment, machinery, raw materials,

products, and, in addition, the financial resources of an organisation that are in its possession or can be acquired. Intangible resources cover management and technological skills, consisting of the skills of individuals, groups, and their organisation. Furthermore, resources such as the company's name, tradition, brand, contacts, and location are highlighted here. The company's skills play an extremely important role in the level of sustainability reflected in its processes and products, which consist in the knowledge and experience of the chief executive, middle management, R&D staff, as well as technicians and labourers. The use of knowledge is becoming widespread and global. It affects companies or selected sectors, and also society as a whole, the entire economy, and the links between countries and societies around the world. Change is happening at a very fast pace and has a significant impact on global economic and social processes.

Enterprises that want—through their activities—to contribute to the creation of social welfare and environmental protection must create an appropriate system for the implementation and development of processes related to knowledge [23]. At the same time, in a knowledge-based economy, knowledge management is an important factor generating income [19]. It should be emphasized here that, despite the intensive work carried out in recent years related to the analysis and characterization of knowledge management and its impact on sustainable development, the need to fill the existing knowledge gap in this area is still emphasized [24,25]. The development of knowledge management should be considered as one of the most important factors affecting the way modern business operates sustainably worldwide [26]. Both the effective use of existing knowledge and the creation of new knowledge are important in order to achieve success [27]. As Drucker stated, one of the primary characteristics of good management is a company's ability to learn. At the same time, he pointed out that, unlike in the 20th century, when the most valuable resource of a company was its means of production, in the 21st century the most valuable resource of an organisation is the workers' knowledge and productivity. These types of employees do not need to be managed but rather follow a leadership, and the working conditions should ensure that they are able to fulfil their potential to the fullest [28]. Wriston, on the other hand, stated that the new source of value is not material—it consists in information and knowledge put into the work of creating value [29]. In this context, Toffler states that the value of effective companies is primarily related to their possession of strategic skills related to the acquisition, creation, distribution, and exploitation of knowledge [30], while Hu and Randel emphasise that the ability to learn and develop as well as the transfer of knowledge are considered critical issues for the growth and survival of organisations as well as in terms of developing a competitive advantage [31]. Knowledge has become a direct competitive advantage for businesses offering ideas and associations [32]. Knowledge management enables knowledge to be created, shared, and applied to achieve corporate objectives [33]. It provides a tool to organisations to implement innovation strategies that can improve the overall performance of the organisation. Enterprises with the right knowledge management can achieve greater growth and are more competitive when compared to others in the market [34]. At the same time, it is the basis for understanding the processes taking place in the environment, the relations between the various market players, and the effects of the various resource allocation models, which, in consequence, leads to a competitive advantage.

The role and importance of knowledge and knowledge management are confirmed not only in a theoretical but also in a practical context. Knowledge has been proven to be a strategic resource of any organization and a key ingredient of the core competences leading to competitive advantage [35]. Knowledge management companies are also successful because they are strictly customer-oriented [36], strive for employee empowerment and the use and development of employee potential [37], focus on continuous process improvement [38], and are associated with the development of an open-learning-oriented organisational culture [39]. The results of a study conducted by the American Productivity & Quality Center in large corporations with an established and reputable market presence

evidenced the existence of a high impact of knowledge management on the innovative potential of companies.

Nonaka and H. Takuchi point out that knowledge is created through information, while information is a stream of data that is the basis for the creation of new knowledge, i.e., further knowledge [40]. Simultaneously, they divide organisational knowledge into three basic categories:

- Personalized core of knowledge (explicit and implicit knowledge);
- Codified knowledge (documentation, reports, publications, databases, and projects);
- Well-established applied knowledge (processes, services, products, relationships, and technologies).

Implicit knowledge is subjective. It flows from experience, it is difficult to copy, and is simultaneous in nature. Explicit knowledge, on the other hand, is objective and it flows from rational thought [40]; it can be expressed in a natural or symbolic language and transferred in verbal and written communication in any social context [41].

In the context of the use of knowledge as an enterprise resource, questions are often asked about the characteristics of knowledge, among which the following should be pointed out in particular:

- Intangibility, elusiveness in a tangible sense;
- Indefiniteness (primarily in terms of application, effects, outlays, and risks of its application);
- Linking (most often) with employees with free will;
- Diversity of methods of creating knowledge, difficulty of capturing and full use, dynamics, affecting the level of risk of projects, externalising and materialising in products and services, and constituting a separate product;
- Dominance (prioritised place among other resources), inexhaustibility (the value of knowledge resources does not decrease when it is transferred), simultaneity (it can be used by many people at the same time, in many places at the same time), non-linearity (there is no clear correlation between the size of knowledge resources and the benefits of this fact) [30];
- Agility (the ability to identify and effectively use opportunities emerging in the organisation's environment);
- Orderliness, complexity, dependence on the context and the person using it, reflected in models of conduct, and synthesis [42];
- Character variability, volatility, development, summation, aging, and devaluation;
- Relativity and ambiguity, implementation in practices, organisational structures and processes, structuring in technological, organisational documentation, and databases.

Diversity and different approaches to the knowledge resource are also visible in the context of the specified types of knowledge. Using the results of their work, Nonaka and Takeuchi [40] distinguished between implicit knowledge (quiet, natural, silent, and implicit) and explicit knowledge (accessible, expressible, and explicit). Implicit knowledge is embedded in the minds of employees, it impacts the nature of people's actions and decisions, and its transmission is often through observation [43]. This type of knowledge is personal, context-specific, and difficult to formulate, capture, and communicate. Tacit knowledge has a significant impact on the innovative capacity of enterprises and on the effective transformation of possessed skills and resources into products [44]. Explicit knowledge can be fairly simply documented, transferred, and traced between organisational units verbally, through computer software, or in the form of patents, diagrams, and information technologies [45]. For today's businesses, the invaluable organisational capital of companies is the implicit knowledge accumulated by their employees [40]. The use of implicit knowledge, by definition inaccessible to all, makes it possible to develop more sustainable [46] competitive advantages, based on elements that are difficult for competitors to identify [47].

Taking into account the 'belonging' of knowledge to a person, personalised (implicit) and codified (explicit) knowledge can be identified. The focus on personalisation is linked to assigning central importance to implicit knowledge, linked to the intuition, intelligence,

and abilities of employees. This strategy assumes that knowledge is linked to the person who owns it, develops it, and shares it. The codification strategy is based on available knowledge. Employees supplement the previously developed knowledge from books, reports, or databases with their own insights and experiences. Learning helps transform implicit knowledge into explicit knowledge [48].

The knowledge management process must be supported by an appropriate organisational solution for the smooth flow of the communication system [49], overcoming barriers in technology transfer, such as the lack of a social network [50], proper and synergic allocation of resources [51], or avoiding data and information transfer without taking into account the context in which they were created. It should also allow the effective elimination of barriers in knowledge transfer, i.e., preferring one's own ideas and studies, or a low level of interpersonal relations [51]. It is also of key importance for the effectiveness of implementation, functioning, and modification of knowledge management processes by proper leadership based on the principles of ethics affecting the well-being of employees [52] and their motivation to engage in pro-social activities [53]. Managers should become leaders who, through their charisma and actions that are an example for employees, encourage their subordinates to actively participate in the implemented processes. An element supporting managers in these activities must be a properly structured organisational culture favouring appropriate values, attitudes, and patterns of action [54], shaping friendly relations between employees [55] and a high level of interpersonal relations [51], fostering teamwork and continuous learning [56], and creating good social conditions including trust, shared values, and a good will to share knowledge [57]. Effective knowledge management is largely based on employee relations and mutual trust [58]. Without these elements, many knowledge management barriers cannot be broken. Therefore, it is important for enterprises to create efficient social networks [50] using both formal and informal channels of information [51], supporting, in particular, knowledge sharing processes. Also important in this context are appropriate social relations allowing for the development of a common language (which facilitates communication), the recognition of who has knowledge and to what extent (leading to the reduction of search costs), raising the level of trust, and creating a network of mutual commitments facilitating asking for help or providing assistance to others [59]. Crucial for the effective inclusion of employees in knowledge management processes is an effective incentive system based on effective measures and ways of influencing employees [60]. An element supporting both the motivation of employees and their trust in the company and co-workers is the existence of properly organised and interlinked assessment and incentive systems allowing for the inclusion of knowledge management issues (with high priority) [56] and rewarding employees actively involved in knowledge creation and sharing processes [61]. Also important is building multifunctional teams, which will provide teams with a broader range of knowledge, perspectives, and skills [62], creating conditions conducive to teams using their diverse knowledge [63], improving processes and practices, delegating powers [64], creating positive interdependence in the implementation of common goals [65], empowering employees, and increasing the sense of control and self-efficiency in situations where employees receive power [66]. The area of cooperation between employees should be supported by the use of innovation platforms where community users communicate and share ideas [67], along with incentive schemes for employees to actively participate in these platforms [68]. It is also necessary to ensure the proper organisation of work taking into account the appropriate spatial density and the number of physical barriers, and facilitating interactions between contractors [35] and appropriate characteristics of the physical workstation (e.g., spatial density, number of barriers surrounding the user's workspace, and interpersonal distance) [69].

Sutton and Preffer point out that there is a large disparity in companies between the actual level of knowledge possessed and the knowledge used in a practical way, and the increase in knowledge stock does not translate into changes in management. The reasons for this are, among others, the following [70]:

- Well-established competitive behaviour patterns in companies, which hinder the free exchange of experiences;
- Preferring familiar and standard solutions based on educated routines, which limits creativity and openness to new ideas and concepts;
- Improperly constructed or incorrectly implemented organisational culture based on an authoritarian management style that does not support cooperation, mutual trust, or a good atmosphere.

In general, the number of barriers to be overcome during the implementation of a knowledge management system depends on several different factors, i.e., company size, market specifics, previous experience with knowledge management, etc. The totality of activities undertaken by the company as part of its management processes should make it possible to overcome barriers to knowledge sharing, one of the most dangerous of which is the fear of a loss of power or status [71]. In many cases, whether as a result of a lack of mutual trust or a misunderstood rivalry between employees, an individual may deliberately conceal knowledge requested by another person [72], which may adversely affect the creativity [73] and productivity [74] of the knowledge seeker. A significant problem, especially for international corporations operating in many countries, may be the proper consideration of the specificity and complexity of cultural and social patterns. This may lead to incorrectly constructed or implemented organisational culture [75], an exposure to negative features related to national culture, or a failure to take into account local social specificities [76]. Effective knowledge management requires employees with appropriate competences, capable of independent and team functioning. A problem in this context may be a low level of mutual trust making the transfer of knowledge more difficult [77], or an incorrectly conducted recruitment process expressed in conflicts based on differences in the individual characteristics of employees [78]. The process of selection of employees must take place not only at the level of the entire company, but also at the level of teams, since in improperly built teams differentiation causes misunderstandings and conflicts, and threatens team cohesion instead of leading to positive effects [79], or it promotes power disparities where strong members can maintain dominance, hindering the realisation of the benefits expected as a result of diversity [80]. The lack of competence among employees or the lack of the required company resources may also lead to low user participation in innovation platforms and no contribution to virtual communities [81].

Factors affecting the nature of the knowledge management solution applied in the company include:

- The size of the enterprise [82]. In large enterprises, there is often a better allocation of resources—especially financial resources [83]—and more efficient mechanisms to support innovation, while in smaller enterprises there are fewer difficulties in the implementation of business and IT functions, as well as limited formalization of activities conducive to the strengthening of interpersonal relations, thus facilitating the exchange of knowledge and experiences [84].
- A priority type of knowledge within the knowledge management system (explicit or implicit) [85].
- The level of centralised management. In centralised management, the initiative is on the side of management, IT solutions are intensively used, and a large emphasis is placed on the codification of knowledge. In decentralised management, there is a focus on personalised knowledge and on giving it a more practical form that is easier to use [86].

The research results available in the literature indicate the existence of a relationship between the practices used by enterprises in the field of quality management and the effectiveness of knowledge management processes [2,87,88]. Some authors even indicate that the processes of quality management and knowledge management have common goals and principles [89], and the consequence of implementing total quality management (TQM) practices in the company is the creation of quality management processes [90]. Stewart and Waddell [91] asserted that enriching the intervention of quality to a wide range of business

processes, including product specifications, customer needs, and continuous improvement, indicates a clear relationship between quality management and knowledge management.

It was found that there is a relationship between quality management practices and such elements related to knowledge management as training and development of employees, teamwork, customer focus [92], process management, strategic planning, human resource management [93], acquiring knowledge from customers, sharing knowledge between employees [94], creating and disseminating knowledge [95], strengthening organizational culture [96], documentation, and data analysis [97]. Hung et al. [98] revealed that TQM enhances the relationship between knowledge and innovation. Companies that successfully implement quality management, including knowledge management, in their operations earn a high-profit share [99].

It should be noted, however, that although the relationship between quality management and knowledge management systems is analysed, it is most often in the context of a selected area of knowledge management, which leads to an incomplete picture of this relationship. In addition, there is still no consensus on the nature of these relationships. While some researchers focus on the mutual relationship, others see quality management as a key factor in implementing quality management practices or quality management as an element supporting knowledge management [100]. There are also no studies defining the relationship between quality management and knowledge management relating to the Polish metal industry. Therefore, taking into account the research results available in the literature and assuming the possibility of certain analogies between the results of these studies and the situation in the Polish metal industry, a decision was made to attempt to fill the research gap by providing answers to specific research questions:

- Which of the eight quality management factors most often affect independent activities that improve the performance of work in metal enterprises in the context of sustainable human resources management?
- Which of the eight quality management factors most often contribute to the sharing of knowledge in a team in metal industry enterprises in the context of sustainable human resources management?
- Which of the eight quality management factors affect the modification of existing procedures?
- Which activities (if any) related to eight quality management factors are most often used when implementing the practices developed in the company in the context of sustainable development?
- What impact do the characteristics of the respondents have on the assessment of the importance of factors?

These questions formed the basis for the following hypotheses of this thesis:

H1: *The priorities applied in the metal industry as part of quality management principles related to the specificity of the activity resulting from the size of the enterprise affect the nature of activities undertaken both by the enterprise and its employees within individual areas of knowledge management in the context of sustainable human resource management.*

H2: *There are certain patterns of conduct within the eight quality management principles characteristic of all enterprises operating in the metal industry, regardless of the scale of their activity and the quality of their human resources.*

H3: *The level of knowledge and experience of employees in metalworking companies affect the nature and scale of activities under the eight different quality management principles in the context of sustainable human resource management.*

3. Characteristics of the Metal Industry in the Context of the Need to Improve Knowledge Management in Poland

The metal industry in Poland focuses its activities mainly on the processing of steel and any derivatives. The value of sold production of the industry producing metals and metal products in 2022 amounted to over PLN 186,947 million and was 40% higher compared to 2017, in which it reached the value of PLN 133,111 million [101]. At the same time, this

production is carried out with the participation of about 2200 companies involved in the production of metals. In total, about 67,000 people are employed in metal companies in Poland [102]. The metal sector in Poland is mainly made up of small and medium-sized businesses (80%) that carry out orders in an integrated format (exchange of know-how, exchange of orders, etc.). Specialisation in the metal industry is actually a continuous trend. Both national and international players producing and machining metal components need to pay close attention to the potential of the industry due to the constant competitive struggle [103]. Steel is currently experiencing a renaissance, especially in the construction sector, which builds lightweight steel structures such as storage, agricultural, sports, and commercial halls. For steel, there are virtually no architectural restrictions [104]. The quality of steel is also improving, making it increasingly popular. The structure of consumers' needs is changing and they are looking for personalised products. Small series and very high quality are the most important aspects in the development of the metal sector in Poland [105,106]. Orders for dedicated sports equipment, music, home décor items, or even collectible militaria are very popular. So today's market is placing new and increasingly specialised demands on businesses, forcing them to be more competitive. Every metal industry enterprise striving for its own development and conducting business activity is forced to search for and create new innovative solutions. In Poland these mainly include investments in innovations of an endogenous nature, primarily in new machines, new production technologies, and the production of automation systems. A small number of companies carry out their own research and development work, usually in collaboration with academic institutions. They develop production technologies, machines, and product prototypes. An important group of particularly frequently mentioned endogenous innovations are production process improvements and management innovations. According to a report prepared by Siemens Financial Services in Poland, one in three metalworking companies plans to increase investment in the renewal of their MiU fleet over the next 12 months [107]. One in four (27%) entrepreneurs also forecast an increase in the level of automation of production processes. Seven out of ten (68.9%) metalworking companies use external financing when making investments in the MiU park. It is worth noting that, compared to 2021, the percentage of companies diversifying their funding sources in 2022 has increased from 26.1% to 54.5%. In 2023, 40% of the industry's manufacturers plan to invest in further machinery and equipment. More than 62% of them would like to invest only in new MiU (the MiU Index is a measure of the "condition of companies to compete" both in the domestic market and abroad) [108]. Currently, however, the biggest challenge that metalworking companies will have to face in order to increase or maintain the competitiveness of their plants is staff shortages. An important challenge for the industry in the next 12 months will also be the need to look for effective ways to reduce production costs, e.g., by reducing the energy consumption of plants or looking for cheaper raw materials [109]. There are also plans to modernise existing machinery and equipment, and to seek sources of funding for such investments [110]. A response to market demand is the emergence of specialised entities and instruments to support innovative ventures, and the commercialisation of R&D work, such as technology parks (23 already in operation), technology incubators (17), technology transfer centres (87), academic business incubators (51), and business angel networks (7). The emergence of seed funds should also be noted (with the significant role of the National Capital Fund), as well as other sources, including those based on private capital, aimed at financing the technological development of the industry [111]. In 2022 alone, from public funds under only one of the many CuBR competitions Poland allocated over PLN 60 million to the implementation of development works and the transfer of their results in the non-ferrous metal industry [112]. The most frequently mentioned barriers to innovation and further growth of the metal industry in Poland are problems of vision and development strategies, the lack of the existence of organisational structures supporting learning, the lack of support for organizational culture and the way of acting with values that strengthen continuous learning, the lack of attachment to continuous improvement of existing processes, the treatment of human

resources as a secondary resource of the organization, the lack of continuous redefinition of processes, the lack of an implemented employee performance management system, the lack of an implemented competence management programme, the lack of treatment of leadership as a key competence of the organization, the low ability to make changes or diffuse knowledge within the organisation, the instability of the law, and and the high costs of implementing new technologies [110]. These are also among the main reasons why companies remain sceptical about Industry 4.0 solutions [113]. Unfortunately, the full transformation of even a small (fewer than 50 employees) manufacturing plant requires a very high level of investment, not only in the sense of financing required to purchase the technology, but also the enormous amount of work required to properly design the processes and change the company culture. The steel industry is the industry of the future, but in order to develop further, business processes must not lack knowledge management as a process of creating value with the help of intangible means at the disposal of enterprises. As the metalworking industry is moving away from standard blue-collar workers to conceptual, decidedly automated work (requiring above-average qualifications and an understanding of specific know-how), knowledge management in the context of sustainable human resource management can help achieve sustainability goals by increasing the efficiency of human and technological resources.

4. Materials and Methods

The research presented here is the result of an analysis of the scientific literature and the identification of a cognitive gap in the area under discussion. This gap is due to the somewhat different approach of the researchers of this issue to the one presented in this study. The available publications contain characteristics of models, factors, barriers, indicators, and methods used in knowledge management processes, but do not examine their impact on sustainable human resources management.

The study included the following stages:

1. Analysis of scientific literature, the purpose of which was to obtain the most concise summary of information from as many available literature sources as possible and to identify the research gap.
2. Preparation of a research tool in the form of a questionnaire containing a total of eight elements within four criteria. The analysed criteria were based on four areas of the Japanese model of knowledge management: independent activities improving the performance of work (in combination with socialisation—compassionate knowledge) (K1), sharing knowledge in a team (externalisation—conceptual knowledge) (K2), modification of existing procedures (combination—systematic knowledge) (K3), and implementation of practices developed in the enterprise (internalisation—operational knowledge) (K4). Within each of the criteria, the same set of elements resulting from eight quality management principles were examined: continuous improvement (A), resource management (B), management of related processes (C), customer orientation (D), responsibility of management/employees (depending on the position held by the respondent) (E), identification of processes and determination of dependencies between them (F), implementation of the product (G), and mutually beneficial relationships with suppliers (H). Respondents were asked to rank each of the eight principles in the context of each area of the Japanese knowledge management model. This allowed the researchers to indicate the relationship between the studied aspects of knowledge management and quality management. At the same time, it allowed the researchers to determine the impact of individual quality management principles on the elements of the knowledge management system.
3. Implementation of the questionnaire surveys. This stage was relatively long (from March to August 2021). In order to check the comprehensibility and transparency of the questionnaire, test surveys were conducted among the selected group of respondents, and the results obtained together with consultations with employees allowed for the modification of the original version of the questionnaire.

4. Data analysis using available and appropriately selected statistical methods. The results of the questionnaire were analysed using Cronbach's alpha test to determine the reliability of the survey tool used. The conducted analysis allowed the researchers to confirm the reliability of the survey—the value of the test was at the level of 0.96. The results obtained were subjected to a statistical analysis using:

- Asymmetry coefficient:

$$W_a = \frac{\mu_3}{s^3(x)}$$

where

W_a—classic asymmetry coefficient
μ_3—the third central moment is calculated according to the formula

$$\mu_3 = \frac{\sum_{i=1}^{n}(x_i - \overline{x})^3}{n-1}$$

- Kurtosis coefficient:

$$W_k = \frac{\mu_4}{s^4(x)}$$

where

W_k—kurtosis coefficient
μ_4—the fourth central moment is calculated according to the formula

$$\mu_4 = \frac{\sum_{i=1}^{n}(x_i - \overline{x})^4}{n-1}$$

5. Interpretation of research results and development of final conclusions referring to the existing scientific research.

A total of 1930 people employed in 50 manufacturing companies in the metal industry in Poland were surveyed. The selection of research facilities was deliberate and, as a result, the study included 25 large enterprises and 25 medium-sized enterprises. The characteristics of the study population of workers are shown in Table 1.

Table 1. Summary of characteristics of the studied population of employees.

Criterion	Category	Large Enterprises [%]	Medium-Sized Enterprises [%]
Age	18–25 years	7.6	29.8
	26–35 years	16.5	36.8
	36–50 years	43.0	22.8
	Above 50 years	32.9	10.5
Type	1–5 years	10.1	52.6
	6–15 years	17.7	28.1
	Above 15 years	72.2	19.3
Position	Production worker	94.9	93.0
	Manager	5.1	7.0
Education	Primary	10.1	8.8
	Basic	50.6	17.5
	Secondary	31.6	50.9
	Higher	7.6	22.8

5. Results

The results of the research are presented in the article in two main parts. The first of these contains results related to hypotheses 1 and 2. The second part presents the statistical analysis related to hypothesis 3.

5.1. Analysis of the Impact of the Size of the Enterprise on the Applied Strategic Patterns

According to the adopted methodology, the first criterion assessed was "independent activities improving the performance of work". The results are summarised in Table 2 (the values of the ratings most frequently indicated for each element and research group have been shaded).

Table 2. Summary of test results for the criterion "independent activities improving the performance of work".

Group of Companies	Evaluation	Tested Elements [%]							
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Large	1	0.0	7.6	24.1	11.4	3.8	7.6	11.4	34.2
	2	2.5	0.0	7.6	8.9	5.1	20.3	49.4	6.3
	3	8.9	12.7	11.4	11.4	12.7	20.3	13.9	8.9
	4	11.4	22.8	11.4	17.7	24.1	6.3	6.3	0.0
	5	27.8	16.5	8.9	21.5	13.9	2.5	1.3	7.6
	6	8.9	6.3	26.6	13.9	10.1	13.9	10.1	10.1
	7	12.7	16.5	7.6	11.4	7.6	11.4	6.3	26.6
	8	27.8	17.7	2.5	3.8	22.8	17.7	1.3	6.3
Medium-sized	1	5.3	8.8	17.5	5.3	12.3	10.5	17.5	22.8
	2	5.3	12.3	19.3	15.8	7.0	14.0	21.1	5.3
	3	3.5	17.5	10.5	7.0	17.5	14.0	14.0	15.8
	4	5.3	10.5	12.3	10.5	15.8	15.8	15.8	14.0
	5	8.8	7.0	8.8	15.8	21.1	15.8	14.0	8.8
	6	19.3	15.8	14.0	12.3	3.5	17.5	10.5	7.0
	7	21.1	17.5	12.3	15.8	7.0	7.0	5.3	14.0
	8	31.6	10.5	5.3	17.5	15.8	5.3	1.8	12.3

The results showed that there was a difference in the distribution of responses for the two groups of companies. For employees of large companies, "continuous improvement" (A) and "responsibility of management/employees" (E) are of the greatest importance for the area indicated. For employees of medium-sized companies, "continuous improvement" (A) and "customer orientation" (D) are of the greatest importance for the area indicated. The least important for employees in both groups of companies is implementation of the product (G).

The results obtained were subjected to statistical analysis allowing the researchers:

1. To build a series of validity (based on calculated averages):

- Large enterprises: A > (B; E) > F > D > H > C > G,
- Medium-sized enterprises: A > D > B > E > (F; H) > C > G.

2. To calculate the slanting and excess coefficients (Figure 1), which made it possible to state that:

- For large enterprises, in the assessment of the elements "resource management" (B) and "identification of processes and determination of dependencies between them" (F), the slant is left-sided (most assessments were awarded above the average). At the same time, there is very little or weak asymmetry in the distribution. In the other factor ratings, the distribution of votes was characterised by a right-sided asymmetry.
- For medium-sized enterprises, in the assessment of elements A, B, and H, the asymmetry of the distribution of votes is right-sided, i.e., very weak to moderate. Only

for the factor "management of interconnected processes" (C) can it be said that the distribution of responses was normal (the asymmetry coefficient is 0.02).

- The excess coefficient for almost all factors in large enterprises takes negative values (which means that the distribution of votes is less slender than normal) and the distribution of votes is characterised by poor concentration around the expected value. In this case, large differences can be observed in the validity assessments granted.

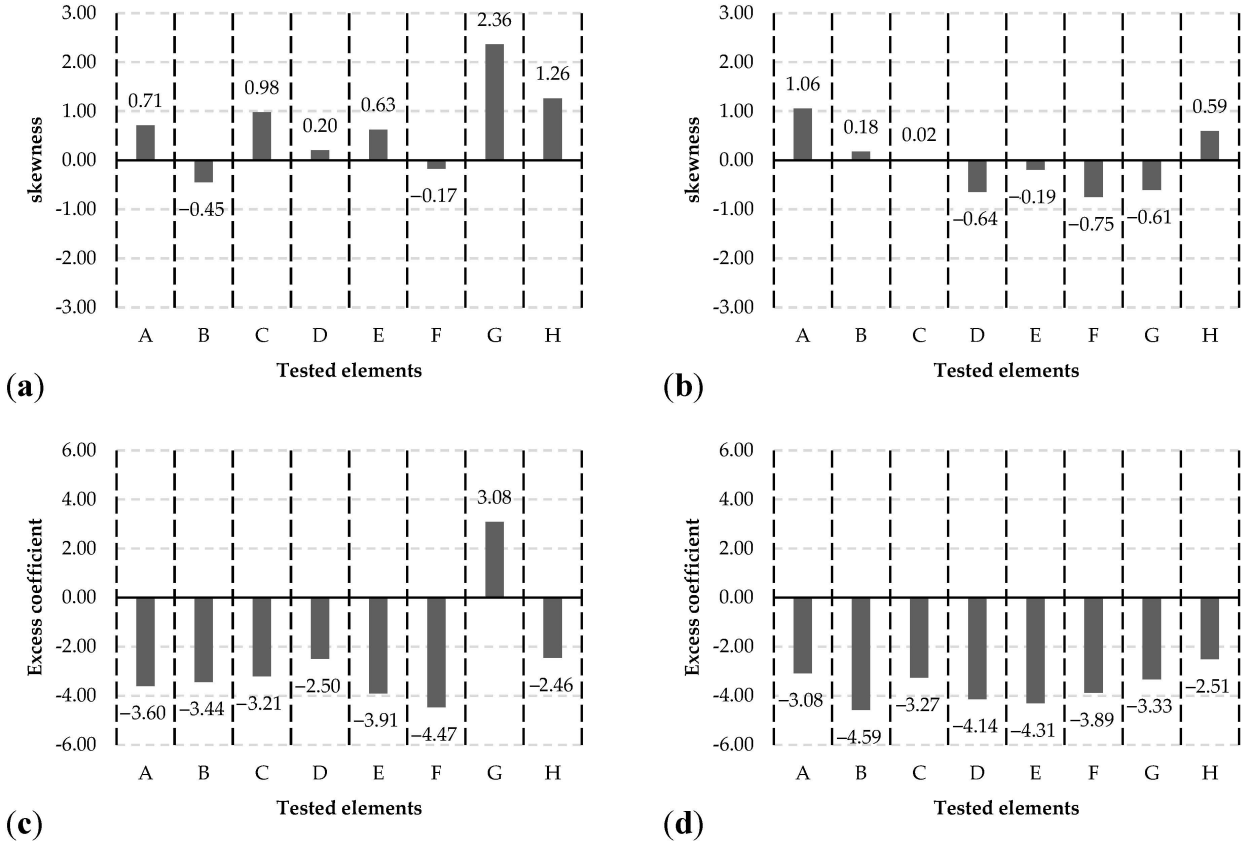

Figure 1. Comparison of slanting and coefficient of excess of factors for the criterion "independent activities improving the performance of work"((**a**,**c**): large enterprises; (**b**,**d**): medium enterprises).

Another criterion assessed was "sharing knowledge in a team". The results are shown in Table 3. The results make it possible to conclude that, in both groups of companies, employees identified two elements as key in terms of the criterion analysed: "continuous improvement" (A) and "resource management" (B). Overall, respondents gave the most ratings of '1' to the factor of "mutually beneficial relationships with suppliers" (H).

Table 3. Summary of research results for the criterion "sharing knowledge in a team".

Group of Companies	Evaluation	Tested Elements [%]							
		A	B	C	D	E	F	G	H
Big	1	17.7	6.3	15.2	11.4	1.3	5.1	10.1	32.9
	2	2.5	6.3	7.6	2.5	6.3	5.1	41.8	29.1
	3	12.7	2.5	17.7	8.9	15.2	25.3	11.4	6.3
	4	3.8	6.3	8.9	2.5	26.6	13.9	20.3	19.0
	5	5.1	7.6	7.6	32.9	16.5	20.3	7.6	2.5
	6	8.9	13.9	39.2	13.9	12.7	5.1	2.5	3.8
	7	15.2	19.0	2.5	11.4	17.7	22.8	3.8	6.3
	8	34.2	38.0	1.3	16.5	3.8	2.5	2.5	0.0

Table 3. *Cont.*

Group of Companies	Evaluation	Tested Elements [%]							
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Medium	1	5.3	3.5	22.8	7.0	10.5	14.0	15.8	21.1
	2	5.3	7.0	14.0	8.8	8.8	14.0	29.8	12.3
	3	0.0	12.3	15.8	14.0	12.3	12.3	15.8	17.5
	4	10.5	14.0	8.8	5.3	24.6	14.0	15.8	7.0
	5	12.3	10.5	12.3	17.5	8.8	24.6	5.3	8.8
	6	15.8	19.3	5.3	15.8	14.0	12.3	7.0	10.5
	7	15.8	10.5	10.5	19.3	14.0	7.0	5.3	17.5
	8	35.1	22.8	10.5	12.3	7.0	1.8	5.3	5.3

The results obtained were subjected to statistical analysis allowing the researchers:

1. To build a series of validity (based on calculated averages):

- Large enterprises: B > A > D > E > F > C > G > H,
- Medium-sized enterprises: A > B > D > E > H > F > C > G.

2. To calculate the slanting and excess coefficients (Figure 2), which made it possible to state that:

- For both groups of enterprises, the asymmetry for all factors is right-sided, which means that all the votes of the respondents were below the average. The asymmetry of the distribution of votes here ranges from moderate to very strong, except for factors E and F, where it is very weak (for large enterprises), and D, where a very weak left-sided asymmetry was found (for medium-sized enterprises).
- The excess factor in enterprise X for "resource management" (B), "management of related processes" (C), and "implementation of the product" (G) adopts positive values, which means that the distribution of votes is more slender than normal. The concentration of results around the mean is high here, indicating a high degree of similarity in the responses given. A similar situation occurs in the case of "responsibility of management/employees" (E) in enterprise Y. Other factors assume a negative value of the excess coefficient, which indicates a large dispersion in the votes.

Another criterion assessed was "modification of existing handling procedures" (Table 4). The responses of employees from large and medium-sized companies were analogous to the previous criterion: "continuous improvement" (A) was considered by respondents to be the most important element, with 44.3% of all '8' ratings. The element with the highest score of '1' in large companies was "mutually beneficial relationships with suppliers" (H), while in medium-sized companies, management of interrelated processes (C).

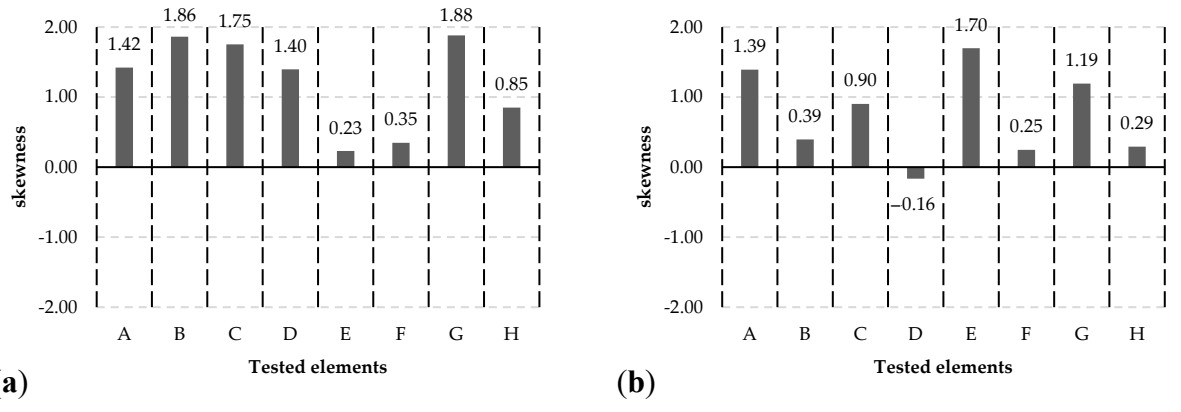

Figure 2. *Cont.*

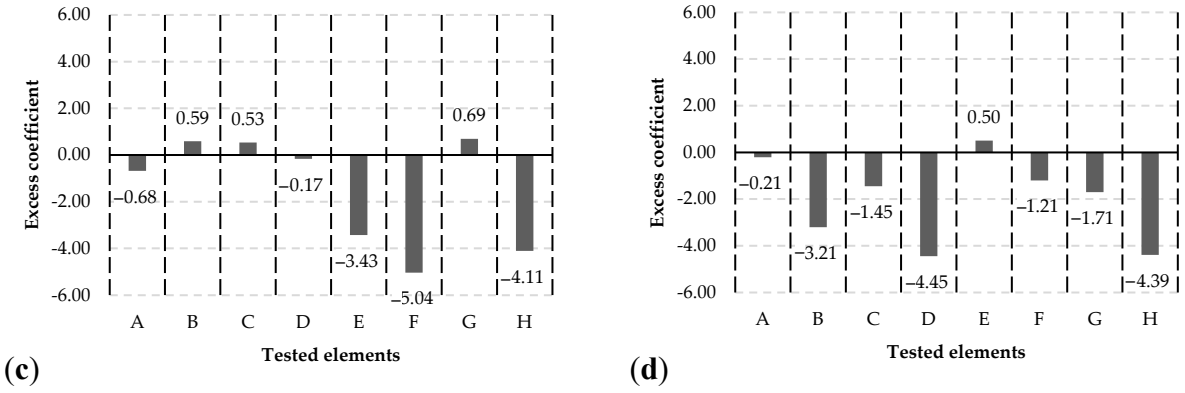

Figure 2. Comparison of the slanting and coefficient of excess of the factors for the criterion "sharing knowledge in a team" ((**a**,**c**): large companies; (**b**,**d**): medium-sized companies).

Table 4. Summary of test results for the criterion "modification of existing procedures".

Group of Companies	Evaluation	Tested Elements [%]							
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Large	1	10.1	2.5	1.3	1.3	1.3	6.3	30.4	46.8
	2	0.0	0.0	7.6	7.6	21.5	17.7	35.4	10.1
	3	2.5	2.5	1.3	5.1	10.1	40.5	12.7	25.3
	4	0.0	3.8	12.7	20.3	31.6	16.5	8.9	6.3
	5	5.1	7.6	20.3	39.2	16.5	3.8	5.1	2.5
	6	15.2	11.4	40.5	8.9	10.1	10.1	0.0	3.8
	7	22.8	44.3	10.1	11.4	5.1	2.5	5.1	0.0
	8	44.3	27.8	6.3	6.3	3.8	2.5	2.5	5.1
Medium-sized	1	5.3	5.3	19.3	10.5	8.8	5.3	15.8	29.8
	2	1.8	12.3	15.8	3.5	14.0	15.8	24.6	12.3
	3	7.0	5.3	5.3	22.8	17.5	19.3	19.3	3.5
	4	7.0	14.0	14.0	10.5	19.3	17.5	7.0	10.5
	5	8.8	12.3	12.3	8.8	10.5	21.1	14.0	12.3
	6	22.8	29.8	8.8	10.5	5.3	3.5	8.8	10.5
	7	21.1	12.3	10.5	17.5	10.5	12.3	3.5	12.3
	8	26.3	8.8	14.0	15.8	14.0	5.3	7.0	8.8

The results obtained were subjected to statistical analysis allowing the researchers:

1. To build a series of validity (based on calculated averages):

- Large enterprises: B > A > C > D > E > F > G > H,
- Medium-sized enterprises: A > B > D > E > (C; F) > H > G.

2. To calculate the slanting and excess coefficients (Figure 3), which made it possible to state that:

- For both groups of enterprises, for most of the studied elements, the slant coefficient assumes positive values, which means that the respondents' ratings were below the average value. In addition, it is characterised by moderate to very strong asymmetry. For medium-sized enterprises, only for the elements of "management of related processes" (C) and "identification of processes and determination of dependencies between them" (F), does the slant coefficient assume negative values characterizing the left-sided slant distribution; the asymmetry of the distribution is very weak here.
- The excess coefficient for both groups of enterprises is mainly negative. This means a more flattened distribution of votes than normal and a lower concentration of votes around the average. For large enterprises, it assumes positive values for the elements "management of related processes" (C), "customer orientation" (D), and "identification of processes and determination of dependencies between them" (F). For medium-sized

enterprises, a positive coefficient was found for the following elements: "resource management" (B) and "mutually beneficial relationships with suppliers" (H).

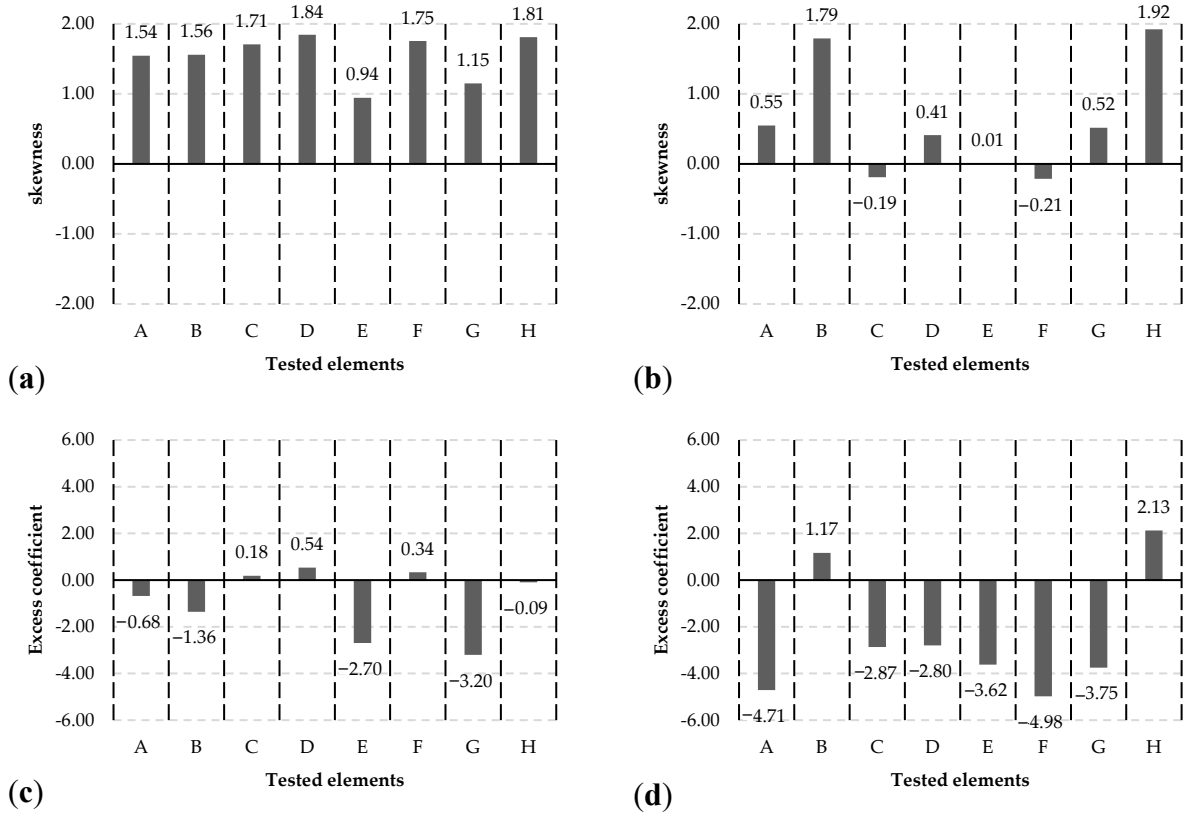

Figure 3. Comparison of the slanting and coefficient of excess of the factors for the criterion "modification of existing procedures" ((**a**,**c**): large companies; (**b**,**d**): medium-sized companies).

Another criterion assessed was "implementation of practices developed in the enterprise" (Table 5). In the context of awarding maximum grades (at level 8), the responses for both groups of companies were found to be consistent ("continuous improvement" (A)). At the same time, it was found, among other things, that the "resource management" element (B) was most often assessed at level 7 by the surveyed medium-sized enterprises whereas in large enterprises this element was most often awarded level 1.

The results obtained were subjected to statistical analysis allowing the reseachers:

1. To build a series of validity (based on calculated averages):

- Large enterprises: C > D > A > B > E > H > F > G,
- Medium-sized enterprises: A > B > D > E > C > F > H > G.

2. To calculate the slanting and excess coefficients (Figure 4), which made it possible to state that:

- The values of the slanting coefficient for both groups of enterprises are mostly positive, which means that the voting distributions are slanted to the right, and most of the given assessments were below the average. Only for medium-sized enterprises for the elements "resource management" (B), "customer orientation" (D), and "identification of processes and determination of dependencies between them" (F), the slanting is left-sided. In most cases, the asymmetry of the distribution is weak or very weak.
- The excess coefficient takes a positive value only for the element of "identification of processes and determination of dependencies between them" (F) in large enterprises. For other factors in large enterprises and in all factor assessments in medium-sized enterprises, this coefficient is negative.

Table 5. Summary of research results for the criterion "implementation of practices developed in the enterprise".

Group of Companies	Evaluation	Tested Elements [%]							
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Large	1	13.9	27.8	6.3	2.5	6.3	1.3	7.6	34.2
	2	24.1	7.6	8.9	11.4	5.1	6.3	32.9	3.8
	3	3.8	5.1	10.1	2.5	19.0	41.8	8.9	8.9
	4	2.5	2.5	1.3	10.1	26.6	20.3	25.3	11.4
	5	6.3	7.6	10.1	21.5	22.8	15.2	13.9	3.8
	6	10.1	8.9	32.9	26.6	8.9	7.6	3.8	1.3
	7	10.1	21.5	8.9	8.9	8.9	3.8	7.6	29.1
	8	29.1	19.0	21.5	16.5	2.5	3.8	0.0	7.6
Medium-sized	1	1.8	10.5	19.3	10.5	7.0	14.0	12.3	22.8
	2	1.8	8.8	19.3	8.8	15.8	12.3	24.6	8.8
	3	5.3	5.3	8.8	15.8	15.8	12.3	12.3	22.8
	4	10.5	15.8	12.3	7.0	19.3	15.8	14.0	7.0
	5	12.3	12.3	7.0	12.3	7.0	22.8	12.3	14.0
	6	15.8	12.3	5.3	15.8	10.5	15.8	17.5	7.0
	7	19.3	19.3	14.0	14.0	14.0	5.3	3.5	12.3
	8	33.3	15.8	14.0	15.8	10.5	1.8	3.5	5.3

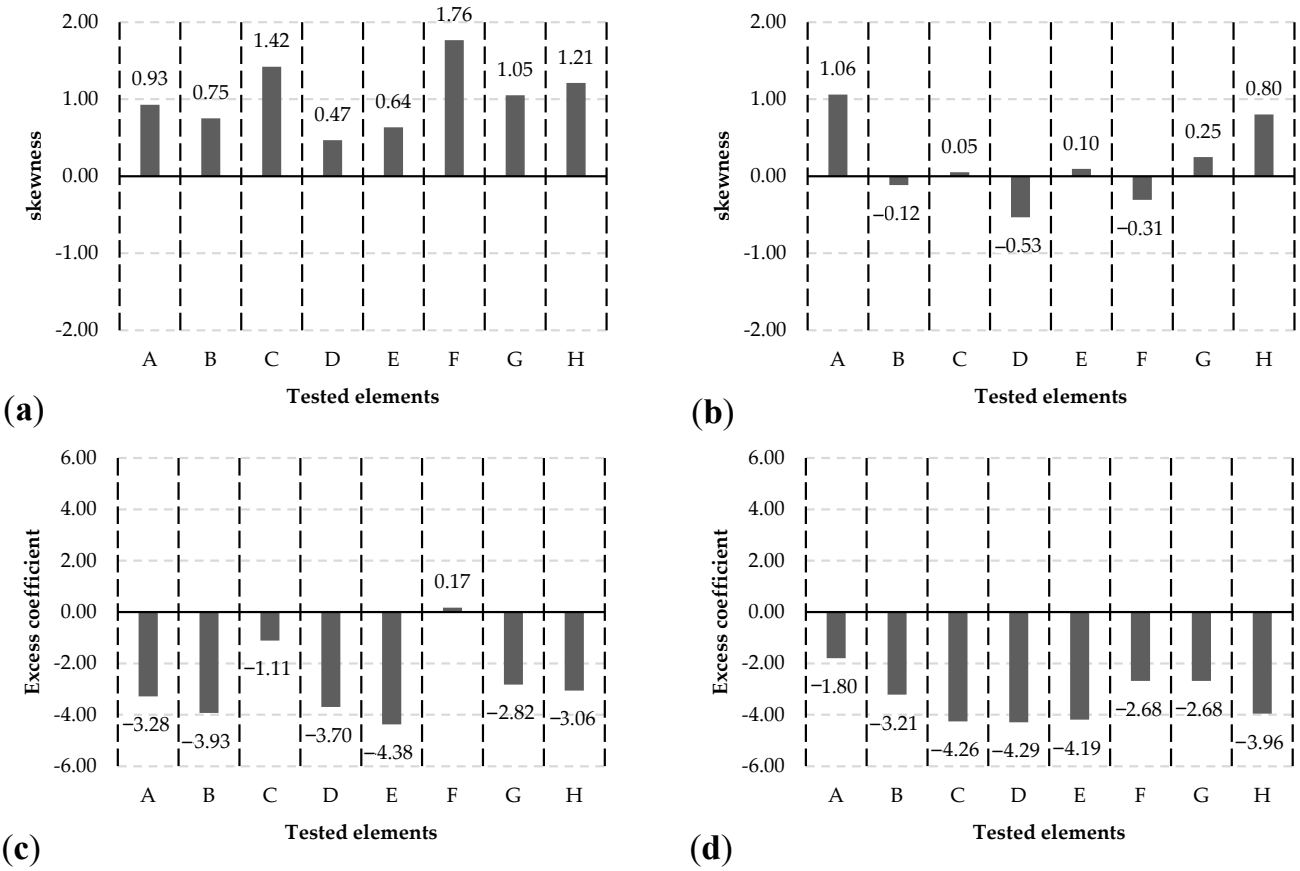

Figure 4. Comparison of the slanting and coefficient of excess of the factors for the criterion "implementation of practices developed in the enterprise" ((**a**,**c**): large companies; (**b**,**d**): medium-sized companies).

The obtained research results allowed the researchers to determine the relationship between the size of the enterprise and the applied strategic patterns in the context of improving processes based on the assumptions of sustainable development. Thus, they allowed the researchers to confirm hypothesis 1.

At the same time, the occurrence of certain patterns of conduct within the examined factors characteristic to all the examined enterprises of the metal industry, regardless of the scale of their activity and the quality of their human resources, was observed. This allowed the researchers to confirm hypothesis 2.

5.2. The Impact of Knowledge and Competences of Employees on Their Perception of the Importance of Specific Improvement Activities

In relation to the obtained results, a statistical analysis was carried out to determine the impact of the respondents' characteristics on the assessments of the importance of factors. Correlation coefficients were calculated using a significance level of $\alpha = 0.05$. The normal distribution was tested and statistical significance was $p < 0.05$ for all data. Due to the lack of normal distribution, the Student's *t*-test could not be used, so its non-parametric equivalent, the Mann–Whitney U-test, was used. For the same reason, the correlation coefficient Spearman's rho, which is the non-parametric equivalent of the Pearson coefficient, was used to calculate the correlation. Statistics will be used for the analyses presented in this chapter.

With regard to individual criteria and the elements examined within them, a number of correlations were found both in the group of large and medium-sized enterprises.

These correlations, which occurred in both groups of the surveyed companies, were analysed more broadly. The following correlations were found:

1. As part of the criterion "sharing knowledge in a team", a negative correlation was identified between the element "management of related processes" and education (Figure 5). For large enterprises, the coefficients were rs = −0.238, $p = 0.035$, while for medium-sized ones, rs = −0.192, $p = 0.040$. Such results imply that an increase in the educational level of respondents contributed to their giving lower ratings to this element.

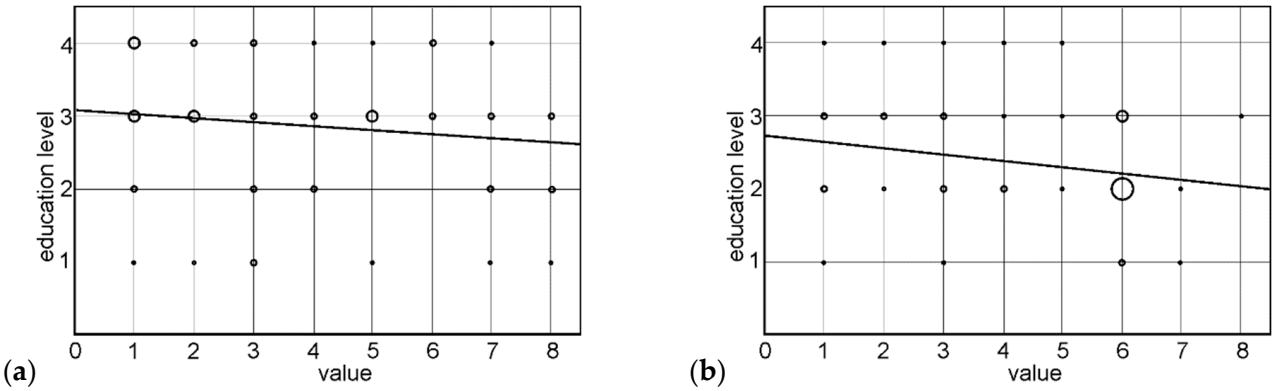

Figure 5. Summary of the results of the correlation analysis for education in relation to the element "management of related processes". (**a**) large companies, (**b**) medium-sized companies.

2. Under the criterion "modification of existing procedures", two correlations were identified:

- Between the element of "continuous improvement" and the number of existing jobs. For large enterprises, the coefficients were rs = −0.294, $p = 0.008$, while for medium-sized ones, rs = −0.216, $p = 0.021$. Such results imply that, for large companies, an increase in the number of existing jobs translated into generally lower ratings given to this element. For medium-sized companies, the situation was the opposite.
- Between the element of "management of related processes" and the level of education (Figure 6). For large enterprises, the coefficients were rs = −0.299, $p = 0.007$, while for medium-sized ones, rs = −0.257, $p = 0.006$. Such results mean that for both groups of enterprises, the increase in the level of education was reflected in the overall higher ratings issued for this element by the respondents.

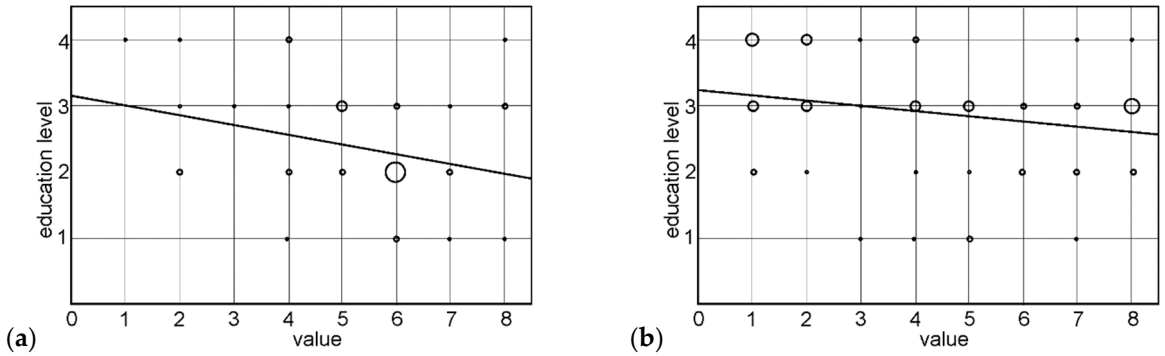

Figure 6. Summary of the results of the correlation analysis for education in relation to the elements "continuous improvement" (**a**) and "management of related processes" (**b**).

3. As part of the criterion "implementation of practices developed in the enterprise", a negative correlation was identified between the element "management of related processes" and education (Figure 7). For large enterprises, the coefficients were rs = −0.228, $p = 0.043$, while for medium-sized ones, rs = −0.275, $p = 0.003$. Such results imply that an increase in the educational level of respondents contributed to their giving lower ratings to this element.

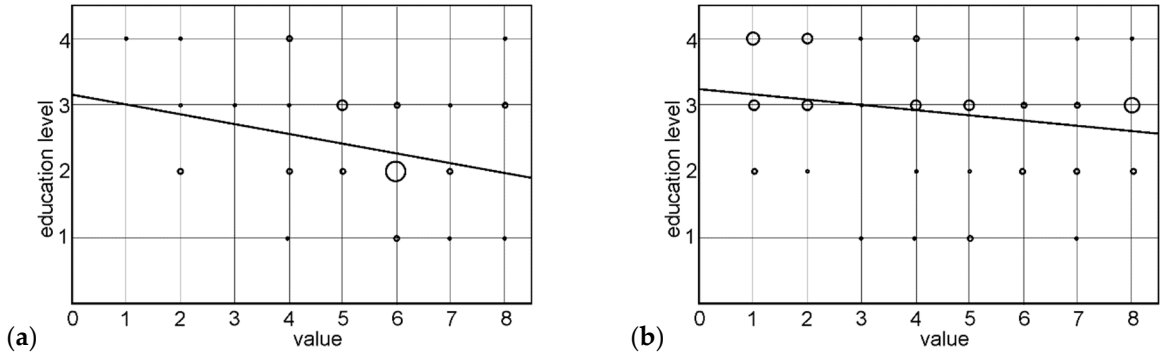

Figure 7. Summary of the results of the correlation analysis for education in relation to the factor "management of related processes". (**a**) large companies, (**b**) medium-sized companies.

The obtained results made it possible to state that the level of knowledge and experience of employees in metal industry enterprises affect the nature and scale of activities under the individual factors of the eight quality management principles in the context of sustainable human resources management. Thus, hypothesis 3 was confirmed.

6. Discussion and Conclusions

In the scientific literature, there is a very large number of studies that contain the terms sustainable development of enterprises or knowledge management in the title. For example, in the Science Direct search engine, after entering the term sustainable development of enterprises for the period 2013–2023, 79,519 results appear. However, if we correlate the terms sustainable development of enterprises and knowledge management in the enterprise in this search engine, the number of studies published since 2013 decreases to 2859 (as of 22 August 2023). Additionally, it can be seen that interest in this issue is increasing, which confirms the fact that in 2022 alone, the number of studies in this area in the database is 400, and by July 20, in 2023, it reached over 300 studies. In fact, there are many forms of enterprise management, which have often been described in the scientific literature. There are several criteria according to which authors divide these forms of management in the activities of business entities. In recent years, many literature reviews have been carried out on topics related to the management of production processes in the face of sustainable development. At the same time, these studies focus mainly on the modelling and analysis of

production systems [114–116], performance calculation tools [117,118], and benchmarking tools and techniques [119–121]. In several studies [122,123], it was emphasized that thanks to a greater concentration on aspects related to sustainable development, enterprises have a chance to grow and improve the quality of innovation and economic results. Therefore, we agree with other authors [29,124–126] that there is no comprehensive analysis of the use of knowledge management methods, rules, and tools to improve the efficiency of processes and the functioning of the entire organization in the context of sustainable development. The quality management methods used to improve production processes that are most often described in the literature do not take into account the elements of knowledge management and their impact on shaping sustainable development in the company [127–131].

Contemporary enterprises that strive to find answers to the needs and market trends more and more often implement practices related to knowledge management. This issue has become an important element of interest for both practitioners and theoreticians, and despite intensive work, there are still areas that need to be supplemented or expanded [24,25]. In addition, studies on the relationship between knowledge management and quality management processes most often concern only selected areas, which makes it difficult to obtain a more complete picture of this relationship, and thus it prevents researchers from reaching a consensus on the nature of these relationships. The present analysis also showed the lack of research determining the relationship between quality management and knowledge management in the Polish metal industry. The conducted research filled the existing knowledge gap in this area, particularly in terms of the impact of quality management factors on the processes of creating, sharing, quantifying, and disseminating knowledge. The influence of the respondents' characteristics on the assessment of the importance of individual factors was taken into account.

The topic of effective knowledge management in the metal industry in Poland in the context of sustainable human resources management is very relevant, especially in the current situation in which employers in the metal industry experience considerable difficulties in finding qualified staff. For example, in Poland, producers of metals and metal products face the challenge of a significant shortage of highly specialised staff in the area of manufacturing processes and must take steps to use them rationally without drastically reducing the level of quality and volume of production or incurring additional costs. Such activities fall within the scope of the knowledge management system. As noted by numerous authors [132–138], modern industrial production in the broadest sense, which also includes social and environmental issues, cannot exist without a sustainability management system. In accordance with the Directive of 16 December 2022 on corporate sustainability reporting (the so-called CSRD), all large entities and small and medium-sized stock-listed companies will have to provide information on environmental, social and human rights issues and corporate governance in their management report. This information will be reported in accordance with the Common European Sustainability Reporting Standards (ESRS). Simplified ESRS will also be developed for small and medium-sized stock-listed companies. At the same time, the implementation of the assumptions of the concept of sustainable development will now require enterprises to modify the assumptions related to the competence profiles of employees. Employees should be aware of the environmental and social impact of their work, and able to make decisions that take these aspects into account. This will also have an impact on modifying perceptions of the role of individual resources and the methods of using them. Increasingly, intangible resources are determining the way in which companies operate and therefore also their competitive position. These processes of change are further compounded by the revolution associated with the implementation of artificial intelligence. As a result, some competences and skills become less relevant, while others, such as those related to understanding the environmental and social impact of business activities, become more desirable. At the same time, the development of artificial intelligence and automation will contribute to the increase in the importance of technical skills and the ability to use data [139]. Simultaneously, however, soft competences, i.e., creativity, analytical thinking, emotional intelligence, interpersonal communication,

continuous development orientation, assessment and decision making, and leadership skills, will continue to be of great importance. Furthermore, a review of the literature in recent years also points to issues regarding the place of knowledge management in contemporary business management [12,140]. Nevertheless, there is a lack of studies relating to how individual methods, principles, and tools of knowledge management affect the efficiency of processes, as well as improving the functioning of the entire organisation in the context of sustainability. Due to the above, knowledge management in the metal industry in Poland in the context of sustainable human resource management has been a poorly researched area of science, which makes it an interesting subject for analysis. This article presents the possibilities of using the Japanese model of knowledge management as an alternative to the expensive and complicated practices of increasing the efficiency of business management from the side of human capital/personnel. It should be mentioned that while awareness of the existence of knowledge and quality management principles is quite common in enterprises, their use in practice—especially in small and medium-sized enterprises—is not so obvious. The results obtained may provide a basis for large and medium-sized enterprises to build certain behavioural models useful in formulating and modifying a strategy in line with sustainable development principles (Figure 8). At the same time, awareness of the importance of individual elements of knowledge and quality management will allow managers, at various levels of the hierarchy, to develop and implement a training plan enabling employees to acquire competences supporting process improvement in the context of sustainable development.

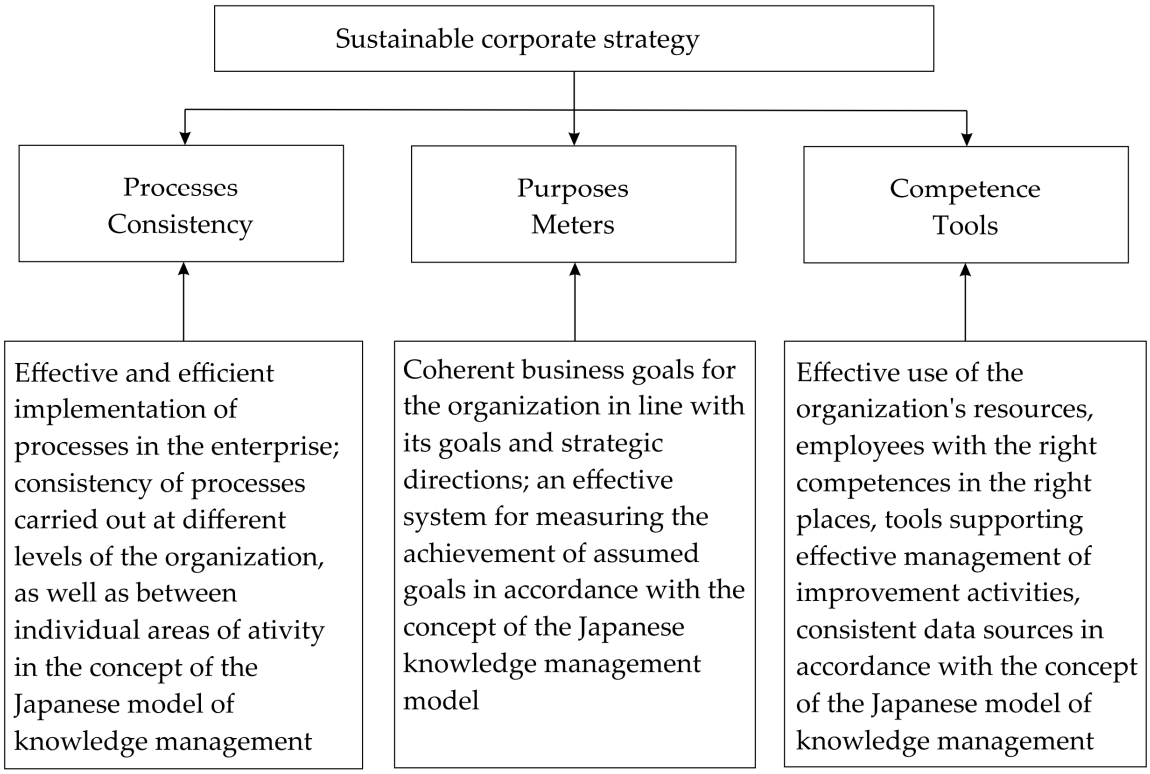

Figure 8. An operational scheme of conduct, as a set of principles defining the way of efficient and effective management of improvement activities, in the context of sustainable human capital management.

The study carried out discovered that in the various areas of the Japanese knowledge management model, companies distribute the emphasis differently, which manifests itself in the procedures and ways of operating. At the same time, there are significant differences between large and medium-sized enterprises, indicating that the scale of operation influences the perception of the importance of individual elements of knowledge management. In the area related to "independent activities improving the performance of work", specific differences were found in the context of the "identification of processes and determination

of dependencies between them"—this element was clearly better assessed in the group of large enterprises. Large differences in assessments were also observed in the area of "sharing knowledge in a team" under the element of "mutually beneficial relationships with suppliers": in medium-sized enterprises this element was rated relatively high, while in the group of large enterprises—surprisingly—this element was rated the lowest. In the area related to the "modification of existing procedures", in large enterprises, "management of related processes" was assigned a much higher rank. Similarly, in the area related to the "implementation of practices developed in the enterprise", this element in large enterprises was indicated as the most important, while in the group of medium-sized enterprises it was at the bottom of the ranking. It should be mentioned that certain elements were indicated as important in all areas analysed. This applies above all to the element of "continuous improvement". This clearly indicates that executives understand the need for continuous analysis of the environment and the constant search for new ways to conduct business and make more efficient use of resources in accordance with the requirements of sustainable development.

Some limitations should be pointed out in relation to the research carried out. Undoubtedly, increasing the research sample would allow for more detailed results. A particularly interesting element, from the point of view of further research work, is the inclusion of enterprises representing other industries in the research group. This would make it possible to identify any differences in the approach to the issues analysed. Given the different specificities of the potential research group's activities, such differences should be expected.

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