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Corporate Sustainability: Impact Factors on Organizational Innovation in the Industrial Area

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Abstract: In recent years, the principle of sustainability has received increasing attention in corporate governance, and corporate sustainability is usually achieved through organizational innovation. The purpose of this study is to identify the factors that are critical for companies to influence organizational innovation when promoting Industry 4.0. Our research analyzes the relationship between these factors and Industry 4.0, human resources, and corporate sustainability to investigate organizational innovation and its formative factors against the backdrop of the new industrial era. Integrating partial least squares-structured equation modeling (PLS-SEM), bootstrapping, and other methods, we discover that for companies focusing on promoting Industry 4.0, the most important organizational innovation that affects sustainability is influenced by customer orientation, organizational culture, and leadership style in descending order of influence. Meanwhile, knowledge integration capability (KIC) is more important than knowledge absorptivity. It indicates that in the promotion of Industry 4.0, the trend of sustainability led by the leaders is fading, and the customer-driven trend will become more and more obvious in the future.

Keywords: corporate sustainability; organizational innovation; formative factors; leadership style; organizational culture; customer orientation; knowledge absorptivity; knowledge integration capability

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1. Research Motivations and Objectives

In recent years, more and more organizations are being asked to become smarter, more efficient, and sustainability-oriented [1,2], and it has recently become a clear trend for companies to pursue sustainability. There is also an increasing emphasis on sustainability principles in corporate governance, which is usually implemented through organizational innovation in Taiwan when promoting corporate sustainability. The study of the patterns that influence organizational innovation and the factors that shape it has received considerable attention and the gradual formation and realization of the Industry 4.0 era will be crucial for corporate sustainability [3]. "Industry 4.0" first became well-known during the Hannover Messe in 2011. Thereafter, it has received wide attention from various countries in recent years. Its core concepts include Cyber–Physical Systems, cloud computing, Internet of Things, big data, lean production, smart machinery, and so forth. Industry 4.0 will move toward a more sustainable industrial value creation, mainly due to its environmental impact on sustainability [4], and it will provide huge opportunities in the economy and society [5]. Industry 4.0 essentially focuses on integrating information and production to render production more intelligent and flexible to market dynamics. Industry 4.0 involves the introduction of new systems in the manufacturing process, with the obvious effect of replacing organizational innovation with job-specific employees. Future business organizations will gradually shift from the current labor-based groups to

highly skilled professionals handling Industry 4.0 technologies. Such technologies require advanced techniques for processing large amounts of data while managing numerous work activities, solving complex and multidisciplinary problems, executing program changes in organizations, and being able to collaborate with robots and handle human–machine interactions [6].

Industry 4.0 will result in a shift of the workforce to higher value-added services, a reduction in standardized low-tech activities, and a change in the organizational culture and customer relationships before and after the change. This study focuses on identifying the factors that influence organizational innovation when companies promote Industry 4.0 and the key factors of the evolution of organizational culture during the promotion process.

Organizational innovation is generally believed to be subject to the influence of the styles of leaders [7] or is engendered by innovation in organizational culture. However, with Industry 4.0, labor forces have transitioned toward high value-added services, activities with less standardized technologies have decreased, organizational culture and customer relations have become increasingly complex, and cross-functional organizations and cross-company partnership networks have increased. The flexibility of Industry 4.0 also helps to shape business model innovation and sustainability [8]. Several scholars have also delved into the influencing factors of customer orientation on organizational innovation [9,10]. However, these studies only looked at one or a few constructs, while only a few studies involved multiple constructs. With the influence of Industry 4.0, organizations would be exposed to a tremendous volume of knowledge and information. Employees are also facing challenges in absorbing and integrating a large amount of knowledge. This knowledge is also a key factor valued by companies [11]. According to Michna and Kmieciak [12], the culture of open-mindedness has both direct and indirect effects on the implementation of Industry 4.0 in SMEs.

Therefore, this study suggests that openness and knowledge sharing can be distinguished as knowledge absorptivity and knowledge integration capability (KIC). Our study aims to compare the influence of both on organizational innovation. Our objectives are as follows:

(1). To study which factor affects organizational innovation more significantly when companies promote Industry 4.0: the top–down "leadership style," the bottom–up "organizational culture", or "customer orientation."
(2). To investigate the impact of knowledge absorptivity and KIC on organizational culture.

2. Literature Review and Hypotheses

2.1. The Relationship between Industry 4.0 and Sustainability

From a technical point of view, most studies agree that the basic concept of Industry 4.0 lies in the connection between the physical system, software, and the Internet of Things (IoT). However, within and between companies, this also implies a new phase of organization and control throughout the product lifecycle value chain [13]. Although initially focused on the manufacturing industry, the impact of Industry 4.0 has recently been extended to other industries, covering every sector and department, and even more so to any company that adopts a data management approach to influence the various processes in its operations [14]. Therefore, Tirabeni, De Bernardi, Forliano, and Franco [15] argue that Industry 4.0 (e.g., logistics, tourism, healthcare) and company operations (e.g., strategic direction, management control systems, organizational structure, enterprise resource planning) should be considered from the perspective of different industries as it relates to the company's vision, policy, strategy, organization, and culture, regardless of the domain [16,17].

Many scholars emphasize the relevance of sustainability to Industry 4.0. On the one hand, Industry 4.0 can conserve resources to achieve sustainability [18]; on the other hand, environmental, economic, and social sustainability is crucial for companies, and therefore,

companies are willing to promote technological and industrial development [19,20]. The effective adoption of Industry 4.0 technologies can reshape organizations, strategies, policies, and operations, and it can promote sustainability at a higher level [21]. The digital technologies adopted by Industry 4.0 with sustainability assessment tools can change the way products are designed, produced, delivered, recycled, and discarded [22]. In this regard, Peruzzini et al. [21] proposed a new Social Life Cycle Assessment (S-LCA) methodology aimed at supporting enterprise modeling and knowledge management to assess company sustainability in the context of smart manufacturing.

2.2. Organizational Innovation

Organizational innovation can be regarded as an outcome of innovation in products [23], while some consider innovation as a process [24]. Sandvik and Sandvik [25] combine the above views by stating that innovation should be defined in terms of both products and processes and that processes and outcomes must be integrated. However, Robbins [26] states that in the past, the focus was only on "technological innovation" of products, processes, and equipment. The author points out that there is a need to incorporate managerial innovation into the definition of organizational innovation. Nowadays, the definition of organizational innovation has increasingly grown broader. However, much of the existing research categorizes it into only two main constructs, namely managerial innovation (including systems, policies, organizations, plans, and services) and technological innovation (including products, processes, and equipment) [27–30]. Nevertheless, several scholars [31,32] also believe that the creation and adoption of new ideas and behaviors by organizations can be deemed as organizational innovation.

Current research on Industry 4.0 focuses on engineering concepts [33] or on industrial chains and organizational refinement [10,34]; there are very few studies that discuss the relationship between Industry 4.0 and organizational innovation. However, in advancing Industry 4.0, organizational innovation is needed to execute planned changes and to be able to work with robots and handle advanced technologies for human–machine collaboration, which are changes that will have an impact on the sustainability of the enterprise [35].

2.3. Leadership Style

True leaders are aware of their beliefs and values and are committed to developing followers and creating a positive and engaging organizational environment [36]. Pierce and Newstrom [37] argue that leadership reveals a dynamic relationship that involves guidance from the leader for members in the direction of the organization's objective. Bass and Avolio [38] define leadership as the action of leaders in their own capacity to influence, motivate, and consider the will of others to work toward an effective and successful organization. In comparison, in Northouse [39]'s definition of leadership, leaders influence a certain group of people and realize a common goal through interaction with members. The author divides leadership into four types of relationships: interaction processes, personal traits, power relations, and organizational goal attainment. Even though leadership has exerted impacts on different aspects in recent years, several scholars still maintain that leadership entails top–down influence to achieve organizational objectives.

However, in recent years, the promotion of Industry 4.0 has even been recognized as socio-technical systems for companies because they involve complex interactions between people and technology in the workplace [40]. In contrast to the top–down approach in which leaders could influence organizational members to achieve tasks, Schulze and Pinkow [41] argue that leaders should promote diversity within organizations to help them adapt, and they should be actively involved in activities that force organizations to innovate and use network structures to expand innovation.

2.4. Organizational Culture

Organizational culture is defined as the norms, values, and behaviors of most employees [42]. Martins and Terblanche [43] argue that organizational culture is a unique

characteristic of an organization and that it functions properly within an organization, is widely accepted by its members, and is expressed in the interpersonal interactions and behavioral norms within the organization. A company's organizational culture would affect how employees behave [44]. With its complexity and profound impact on an organization, organizational culture points to a direction for the organization and may affect its members and the work environment positively and negatively. According to Gallagher, Brown, and Brown [45], organizational culture can impact everything an organization does, including how to operate and treat customers, employees, and shareholders. Furthermore, according to Wu, Lin, and Fu [46]'s definition, organizational culture represents the specific ways of doing things, the values shared among the members of an organization, and the common beliefs for managers to manage business and employees. In this regard, we define this construct as the specific way of conduct and values shared by members of an organization. Members can influence organizational culture through common beliefs, thus offering directions for development through a bottom–up approach.

Kiel, Müller, Arnold, and Voigt [19] confirmed that the changes induced by Industry 4.0 cannot ignore the model of organizational change. They interviewed 46 manufacturing leaders from different countries, and more than half of them considered organizational innovation necessary to make the Industrial Internet of Things work. Davies, Coole, and Smith [40] expanded the definition to include Industry 4.0 as "socio-technical systems", emphasizing the people and machines in the system and the surrounding environment. All organizational levels need to be re-evaluated and redesigned to develop new technologies [47]. Furthermore, cultural barriers must be considered when redesigning company organizations, and culture must support the adoption of Industry 4.0 [14,19]. In reality, this will be met with resistance, reluctance to change, and emotional reactions from the company organization, which will likely severely impact the adoption of smart factory technologies [48].

2.5. Customer Orientation

Luo, Hsu, and Liu [49] believe that an organization's customer orientation means that employees can use marketing to help customers make satisfactory purchase decisions. Hennig-Thurau [50] find that customer-oriented sales personnel can more precisely identify the needs of customers and thus provide better services. Furthermore, Kotler [51] contends that companies should not only pursue the best customer services but also foster a strong agency–client relationship with consumers. To indicate customer orientation, many existing studies chose customer satisfaction, which reveals the evaluation of products or services by consumers. For instance, Gupta and Zeithaml [52] argue that customer satisfaction is the most common indicator of customer orientation. This is suitable for the quantitative measurement for all kinds of products and services. As there are correlations among customer services, customer orientation, and customer satisfaction, the three concepts are often discussed together. For example, McNaughton, Osborne, Morgan, and Kuttwaroo [53] state that strategies for customer orientation should include listening, providing services, offering commitments, and satisfying customers, as well as striving to improve customer satisfaction.

Other scholars view customer orientation as a drive for organizational innovation. For instance, Tidd, Bessant, and Pavitt [54] consider customer orientation as a formative factor for an innovative organization. Similarly, Wikhamn [55] finds that customer orientation can enhance an organization's innovation ability and increase customer satisfaction. Companies are advised to prioritize customer orientation and develop their innovation abilities using techniques of customer relationship maintenance and external information [56].

The intelligent technologies used in Industry 4.0 enable further information providers and customers [16], which can facilitate connections within the value chain and increase agility in response to environmental changes [57]. To take advantage of this, companies must accurately organize their networks with other companies and coordinate with each other to ensure that the right information is available to target customers [58]. To share

product expectations and expertise, there must be closer relationships between company employees and with customers and suppliers, although only a few studies have touched on this topic [40].

2.6. Top–Down and Bottom–Up Approaches

Top–down and bottom–up approaches have been widely applied to product design, computer science, management and organization, and other areas. These approaches are considered as a way of thinking, of education, or of leadership style. Specifically, the top–down approach can also be termed as a stepwise design [59], stepwise refinement [60], or decomposition [61]. This approach refers to the decomposition of systems followed by an in-depth understanding of the components. While experts using the top–down approach would offer suggestions to influence others, bottom–up coordination can prompt participants to resolve issues that are relevant to themselves [62].

Considering management and organizational thinking, the two approaches are often used to describe the process of formulating and revising decisions. The top–down approach means implementing the decisions of decision-makers. The advantage of this approach lies in the high efficiency and precise description of all levels [63]. However, the disadvantage is that if innovation or reform begins from top–down, it might be difficult for the lower levels to accept it [64]. On the contrary, the bottom–up approach proceeds from the bottom level and involves participatory decision-making. Therefore, this is believed to be a revolutionary method to train and retain frontline staff members [63].

2.7. Knowledge Absorptivity

The concept of organizational learning becomes relevant when organizations face new problems or must adjust the current processes to improve potential behaviors, or to bridge the gap between expectations and outcomes by processing information [65]. Nowadays, an increasing number of companies aim to promote innovation by searching for external knowledge to add to their competitive advantages [66]. A company's knowledge absorptivity has also been emphasized as a potential key for its innovation successes [11]. Learning is related to the acquisition of external knowledge and corresponds to the concept of potential absorptivity [67]. The ability to learn tends to be indicated by the absorptivity and integration capability of external information and knowledge of the organization [68]. Knowledge absorptivity refers to the identification, digestion, and application of external knowledge or information by organizations [69].

Cárcel-Carrasco and Gómez-Gómez [70] consider that industrial activities require very complex technical and human factors to achieve excellent processes or services, and they require the acquisition of a great deal of knowledge. However, the absorption, management, and application of knowledge in this activity are usually forgotten, and the introduction of these competitive advantages should be prioritized for use in the company's activities. The starting point of Industry 4.0 is the visualization of knowledge as a strategic and important element, and it must be considered that organizational processes should be studied through internal organizations, visualizing how knowledge is created and absorbed, and identifying the knowledge they have [71]. The internal organization should be considered to study the organizational processes, visualize how knowledge is created and absorbed, and identify the knowledge they possess [71].

2.8. Knowledge Integration Capability

According to Kogut and Zander [72], KIC suggests that companies are able to integrate knowledge to purposefully create new knowledge and adapt in response to the market. To ensure that the knowledge accumulated can be applied effectively, companies must increase, eliminate, explain, and integrate knowledge [73]. Moreover, to continuously improve and efficiently implement the ideal process of knowledge absorption, companies should learn to institutionalize behaviors of integration [74]. In recent years, knowledge integration has become a strategic advantage for companies and a crucial element for

competitive strategies [75]. Furthermore, such ability can enable companies to combine different inputs for production [76]. Specifically, the integration of knowledge resources is highly relevant for customer-oriented companies, as their missions to satisfy customer needs require adaptability and flexibility so that companies can offer certain services for customers [77]. The complexity in the process of knowledge integration is relevant to the sustainability of competitive advantages [78]. Therefore, many companies have adopted knowledge integration as their strategic leverage in competitive strategies [79].

To promote Industry 4.0, the systems in an organization should fully support and be compatible with all organizational processes [80]. Therefore, the knowledge facing the internal and external areas of the enterprise must be efficiently integrated. For example, the integration of products, physical production systems, and cyber technology will enable monitoring, self-adjustment, and the optimization of resources for production [81]. To continuously improve and efficiently execute the desired knowledge absorption process, firms should learn to institutionalize knowledge integration [74]. In recent years, knowledge integration has become a strategic advantage for companies and a key element of competitive strategy [75]. Knowledge integration capabilities enable companies to combine various production inputs [76]. The complexity of the knowledge integration process is also relevant to sustaining a competitive advantage [78]. Therefore, whether a company has knowledge integration capability (KIC) is indicative for the promotion of Industry 4.0.

2.9. Hypotheses

According to Piccarozzi, Aquilani, and Gatti [82], Industry 4.0 is related to management areas, such as new business models [83] or corporate strategies [14]. As previous research has rarely taken a more interdisciplinary approach, there is a need to analyze corporations from a perspective that can focus on the intersection of these fields, such as appropriate corporate organizational models, sustainable business practices, and the relationship between factors within a corporation that influence each other, such as the ability to apply knowledge within a corporation in relation to sustainability.

Considering the literature, we understand that the relationships between leadership style, customer orientation, KIC, knowledge absorptivity, and organizational innovation vary with different research objectives and subjects. Based on the above empirical evidence, we propose the following hypotheses on the constructs using the top–down and bottom–up approaches:

Hypotheses 1 (H1). *Leadership styles of managers positively correlate with organizational innovation.*

Hypotheses 2 (H2). *Organizational culture positively correlates with organizational innovation.*

Hypotheses 2a (H2a). *Knowledge absorptivity positively correlates with organizational culture.*

Hypotheses 2b (H2b). *Knowledge integration capability positively correlates with organizational culture.*

Hypotheses 3 (H3). *Customer orientation positively correlates with organizational innovation.*

3. Experimental Framework

In order to investigate the organizational innovations and the relationships between their constructs that have influenced corporate sustainability in recent years, this study conducted quantitative research on Taiwanese machinery companies that promote Industry 4.0. We proposed the hypotheses using both the top–down and bottom–up approaches. Here, we divided the formative factors for organizational innovation into the top–down leadership style and the bottom–up organizational culture, and customer orientation, following Stewart, Manges, and Ward [63]. In particular, the determinants for organizational culture are knowledge absorptivity and KIC. Hence, the proposed research framework is established as shown in Figure 1. The questionnaire was adapted from the relevant theoretical literature, and three business managers from different factories offered advice on the

items and meanings of the draft. Then, the questionnaire was tested among 25 machinery professionals and revised. Furthermore, we adopted the partial least squares (PLS) to analyze two models. Firstly, PLS-SEM (PLS-structural equation modeling) was conducted to test the research model and the hypotheses H1, H2, H3, H2a, and H2b. Afterward, we used bootstrapping to examine the effects of different paths in the model to understand the influence of and relationship between factors.

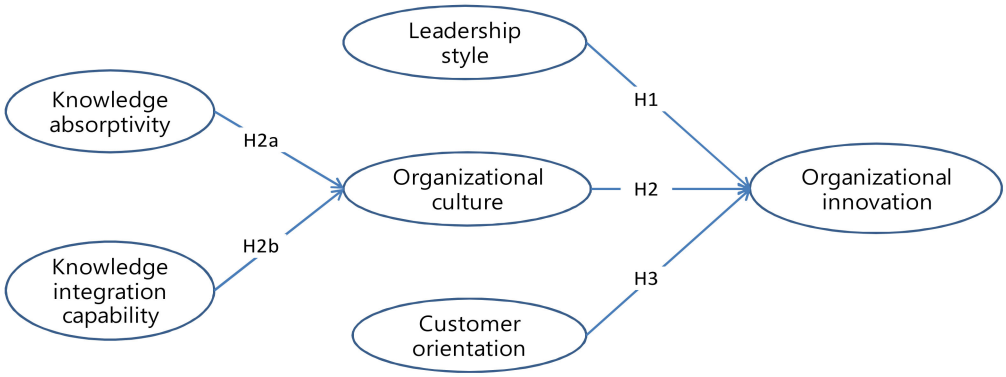

Figure 1. Proposed research model.

3.1. Measurement of Variables

In terms of organizational innovation, although our subjects are from the machinery industries, there are differences in the environment where different secondary industries are located, as well as their technologies. Therefore, objective approaches are not suitable for measurements [84]. Instead, we resorted to subjective self-evaluation to measure organizational innovation. All the items in the questionnaire are listed in Table 1. Specifically, a 7-point Likert scale was used to record the subjective views and feelings of respondents, ranging from "strongly disagree" (1) to "strongly agree" (7). The higher the score, the stronger the agreement from the respondents, and vice versa.

Table 1. Items for measuring constructs.

Construct	Reference	Item
Organizational innovation	Wang and Hsu [85]; Liao, Fei, and Chen [86]; Lin, Huang, and Tung [84]; Tsai, Huang, and Kao [87]); Damanpour and Evan [32];	E1. All units within the company coordinate well with one another. E2. The company allows employees to commute flexibly at various times. E3. My company allows freedom of expression, and opinions are permitted on different levels of a task. E4. My company highly values research and development of high and new technologies. E5. My company has partners across different departments and companies, which inspires thinking in different directions. E6. One is allowed to propose plans of revision of internal work process to facilitate cooperation among colleagues. E7. The company will propose supporting plans to assist employees with high initiative. E8. The company has a strategy to transform the vision into an executable plan. E9. One can discuss an issue in full detail and offer criticism freely. E10. The employees are motivated and passionate about work and are able to influence the team environment.

Table 1. *Cont.*

Construct	Reference	Item
Customer services	Kim, Basu, Naidu, and Cavusgil [56]; Nemec [88]; Garbarino and Johnson [89]; Anderson and Sullivan [90]; Czepiel [91]	F1. Customers are highly satisfied with my company. F2. My company emphasizes greatly the quality of services for clients. F3. The company's customer service needs to be fast and instant. F4. In order to maintain a good relationship with customers, the company has clear practices. F5. Employees are all able to grasp the demands of the clients. F6. Colleagues in my company are often able to take the initiative to interact with external personnel. F7. Colleagues in my company are good at establishing long-term relationships with clients.
Leadership style	Hoch, Bommer, Dulebohn, and Wu, [92]; Hughes, Lee, Tian, Newman, and Legood [93]; Bass [94]	B1. The company can achieve tasks through outstanding leaders in charge. B2. I respect my manager's management style. B3. I trust my manager has the ability to overcome difficulties. B4. My manager is able to motivate my team and me to achieve work objectives. B5. My manager often encourages colleagues in self-growth. B6. The manager will clearly indicate the expectations and requirements of me. B7. When I feel ignored, my manager will express timely concern. B8. When I complete the mission, my manager will offer timely appreciation. B9. My manager is willing to spend time in instructing my work. B10. The manager always persuades me to change my view of the problem in a righteous way.
Organizational culture	Gao [95]; Deshpande and Farley [96]; Ogbonna and Harris [97]; Deshpande, Farley, and Webster [98]	C1. My company is similar to a big family where people share work and life together. C2. The executives in my company behave as mentors or parents. C3. My company emphasizes the importance of teamwork. C4. My colleagues are willing to innovate and take risks. C5. The company's formal rules and regulations are an important force for employees to operate smoothly. C6. The company pays more attention to whether the work is completed than care for the individual. C7. The company emphasizes that employees accomplish tasks and goals above all else. C8. The company values competition and achievement.

Table 1. *Cont.*

Construct	Reference	Item
Knowledge absorptivity	Jansen, Van Den Bosch, and Volberda [99]; Grant [100]; Garud and Nayyar [101]	H1. The internal system of my company is highly informatized. H2. My company will actively incorporate new technologies or new techniques. H3. My colleagues are used to discussing new concepts. H4. The company can easily obtain sufficient information related to the task H5. There is a specific department or personnel in charge of collecting relevant information on Industry 4.0 in my company. H6. The company has implemented complete education and training to promote Industry 4.0 H7. My company has a specific way of making information open and transparent. H8. Most employees of the company have the ability to work with new technologies (Internet, professional...) H9. Employees often join professional knowledge discussion groups.
Knowledge integration capability	Jansen, Van Den Bosch, and Volberda [99]; Grant [100]; Garud and Nayyar [101]	D1. My company has a fair evaluation system. D2. The direction of the development of my company is the same as that of the employees. D3. When employees perform poorly, the company will coach employees to continue to develop. D4. There is no rigid bureaucracy in my company, and flexible changes in the rules are allowed. D5. There is an unblocked channel of promotion. D6. There is an assessment mechanism with clear rewards and punishments in my company. D7. The company has clubs or activities to encourage employees to grow up. D8. Specific methods are taken to encourage employees to bravely voice different opinions or beliefs. D9. Research on new ideas will be given additional rewards in my company.

3.2. Survey Subjects and Methods

Taiwan enjoys globally unique clustered innovation relations. In the three main regions of northern, central, and southern Taiwan, there are 48 industrial clusters [102]. Among them, the machinery industry encompasses final products, components, professional elements, equipment, service suppliers, financial institutions, and relevant company and economic activities that have already formed mature industrial clusters [103]. Furthermore, the World Economic Forum ranks Taiwan first in the world for years in the development index for industrial clusters, serving as an excellent example of innovative development in industrial clusters globally [104]. In 2016, the Taiwanese government and enterprises began to promote Industry 4.0, planning to spend NT$45 billion over the next nine years to help the hidden champions in seven key areas to upgrade to Industry 4.0 in two phases [105]. The rationale for choosing machinery companies as study subjects is that the machinery industry in Taiwan consists mainly of small- and medium-sized enterprises. In their early stage, when the companies are still small in scale, it is usually the founders who service the customers. However, with the growing size of modern companies, the organizational culture of internal governance may vary with the leadership style of managers. Therefore, it is essential for this research to understand whether leadership style, internal organizational culture, and customer orientation would affect organizational innovation.

Due to overlaps in the work of research and development, sales, and services personnel, the population of our sampling was set to consider the above-mentioned personnel. We sampled the factories of companies with the capacity for global supplies, including the FCS Group, Multiplas, and Victor Taichung, whose employees are based in different parts of the world, and thus, are representative. In terms of survey subjects, we focused on frontline employees with communication and interaction with customers. These employees tend to have the most direct experience in customer-oriented behaviors of their company.

4. Results

4.1. Analysis of Samples

The questionnaire was distributed to and collected from individuals from December 12, 2018 to March 4, 2019. A total of 371 questionnaires were distributed, and 271 were returned. Of these, 21 invalid samples were deleted due to excessive missing responses and patterns in the answers. There were 250 valid questionnaires in total, with a valid return rate of 92.25% and a valid sample rate of 71.43%. Among the valid samples, 80% of the respondents (199) are male, and 20% (51) are female. This is in accordance with the gender distribution of the machinery profession. The data of the age of respondents are normally distributed. Regarding the level of education, most have a college or university degree.

The SmartPLS software allows variance-based structural equation modeling (SEM) using partial least squares (PLS) path modeling methods [106]. The software can estimate path models with latent variables using PLS-SEM and can calculate standard outcome assessment criteria (e.g., for reflective and formative measurement models, the structural model, and goodness of fit). In this research, we used the smartPLS software [107] to analyze the survey data and examined the substantial relations between constructs. Specifically, a Lilliefors test (a reformed Kolmogorov–Smirnov test, with the standard of p value > 0.2) was conducted to check if the variables measured have a normal distribution. The test results of the items are demonstrated in Table 2.

Table 2. Items that passed the Lilliefors test.

Construct		Item	p Value	Lilliefors Test
Organizational innovation	E1.	All units within the company coordinate well with one another.	0.807	Passed
	E3.	My company allows freedom of expression, and opinions are permitted on different levels of a task.	0.847	Passed
	E4.	My company highly values the research and development of new and advanced technologies.	0.836	Passed
	E5.	My company has partners across different departments and companies, which inspires thinking in different directions.	0.895	Passed
	E6.	One is allowed to propose plans of revision of internal work process to facilitate cooperation among colleagues.	0.879	Passed
	E9.	One can discuss an issue in full detail and offer criticism freely.	0.875	Passed
	E10.	The employees are motivated and passionate about work and are able to influence the team environment.	0.853	Passed
Customer services	F1.	Customers are highly satisfied with my company.	0.894	Passed
	F2.	My company emphasizes greatly the quality of services for clients.	0.769	Passed
	F5.	Employees are all able to grasp the demands of the clients.	0.887	Passed
	F6.	Colleagues in my company are often able to take the initiative to interact with external personnel.	0.844	Passed
	F7.	Colleagues in my company are good at establishing long-term relationships with clients.	0.780	Passed

Table 2. *Cont.*

Construct		Item	*p* Value	Lilliefors Test
Leadership style	B2.	I respect my manager's management style.	0.884	Passed
	B4.	My manager is able to motivate my team and me to achieve work objectives.	0.870	Passed
	B5.	My manager often encourages colleagues in self-growth.	0.845	Passed
	B7.	When I feel ignored, my manager will express timely concern.	0.879	Passed
	B8.	When I complete the mission, my manager will offer timely appreciation.	0.847	Passed
	B9.	My manager is willing to spend time in instructing my work.	0.823	Passed
Organizational culture	C1.	My company is similar to a big family where people share work and life together.	0.863	Passed
	C2.	The executives in my company behave as mentors or parents.	0.896	Passed
	C3.	My company emphasizes the importance of teamwork.	0.854	Passed
	C4.	My colleagues are willing to innovate and take risks.	0.840	Passed
Knowledge absorptivity	H1.	The internal system of my company is highly informatized.	0.828	Passed
	H2.	My company will actively incorporate new technologies or new techniques.	0.865	Passed
	H3.	My colleagues are used to discussing new concepts.	0.891	Passed
	H5.	There is a specific department or personnel in charge of collecting relevant information on Industry 4.0 in my company.	0.702	Passed
	H7.	My company has a specific way of making information open and transparent.	0.841	Passed
Knowledge integration capability	D1.	My company has a fair evaluation system.	0.856	Passed
	D2.	The direction of the development of my company is the same as that of the employees.	0.840	Passed
	D4.	There is no rigid bureaucracy in my company, and flexible changes in the rules are allowed.	0.792	Passed
	D5.	There is an unblocked channel of promotion.	0.858	Passed
	D6.	There is an assessment mechanism with clear rewards and punishments in my company.	0.848	Passed
	D8.	Specific methods are taken to encourage employees to bravely voice different opinions or beliefs.	0.828	Passed
	D9.	Research on new ideas will be given additional rewards in my company.	0.817	Passed

4.2. Data Analysis

We adopted the PLS-SEM to analyze and examine the logical relationship between hypothesis testing, the measurement model, and the structural model. According to Anderson and Gerbing [108], there are two stages in structural equation modeling. The first is to evaluate the measurement model to understand the reliability, convergent validity, and discriminant validity. The second stage involves the assessment of the structural model to test the hypotheses on the causal relations between various constructs. Here, we used PLS path analysis to test whether H1, H2, H3, H2a, and H2b are supported. Then, to ensure

the rigor of our research, we used bootstrapping to investigate whether each path in the model is close to reality and significant.

4.2.1. Evaluation of the Measurement Model

Concerning the reliability and validity of our constructs, as Bagozzi and Yi [109] suggest, at least three of the following most common indicators should be used to evaluate the measurement model: outer loadings, squared multiple correlation (SMC), variance inflation factor (VIF), Cronbach's alpha, composite reliability (CR), average variance extracted (AVE), cross-loading, and heterotrait-monotrait ratio (HTMT).

In our measurement model, the outer loading of leadership style on organizational innovation (H1) is 0.142, the outer loading of organizational culture on organizational innovation (H2) is 0.294, and the outer loading of customer orientation on organizational innovation (H3) is 0.494; none reach 0.50 and fall short of the general level of statistical significance [110]. As organizational culture is a formative indicator, we were unable to calculate the individual item reliability, CR, or AVE. We find that the outer loading of KIC on organizational culture (H2b) is 0.571, which is higher than 0.50, and thus, it is statistically significant. However, the outer loading of knowledge absorptivity on organizational culture (H2a) is 0.275, which is lower than 0.50, and thus, it is not significant, as indicated in Figure 2. To ensure rigorous evidence, we conducted 5000 times of bootstrapping to test the significance of all the above hypotheses.

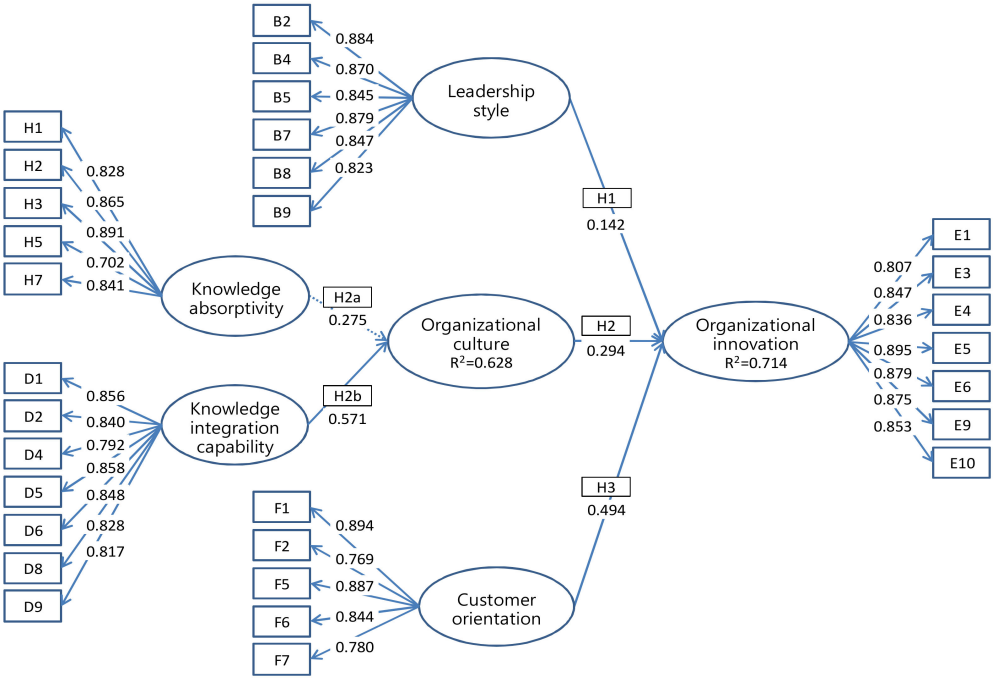

Figure 2. Partial least squares (PLS) model (outer loadings, path coefficient, and R^2).

The results of the individual item reliability are presented as follows. We examined the outer loadings of the latent variables to test the statistical significance of the loading of the variables. All loadings of the variables exceed 0.6 and are significant, while the outer loadings of samples are between 0.70 and 0.90 (see Table 3). Bagozzi and Yi [109] and Hair, Black, Babin, and Anderson [111] argue that researchers should be aware of the SMC of certain items. This indicator is the square of the outer loading of the latent variable. In our study, the SMC is between 0.49 and 0.80, which is lower than the standard of 0.5 in Bagozzi and Yi [109]. However, the value still meets the minimum requirement of 0.4, as suggested in Taylor and Todd [112] (see Table 3). As recommended by Hair, Ringle, and Sarstedt [113], the VIF of each indicator should be less than 5 to indicate that there is no collinearity among variables (see Table 3). In terms of the reliability coefficient α

(Cronbach's alpha), Hair, Black, Babin, and Anderson [111] hold that the α of the overall questionnaire or scale should be more than 0.8, while the subscale should achieve an α of over 0.7. In our study, the reliability coefficients of the questionnaire and scales of the constructs are all above 0.8, indicating good reliability.

Table 3. Composite reliability (CR) and average variance extracted (AVE) of the items.

Construct		Item	VIF	Outer Loading	SMC	CR	AVE	Cronbach's Alpha
Leadership style	B2	I respect my manager's management style.	4.37	0.88	0.78	0.94	0.74	0.93
	B4	My manager is able to motivate my team and me to achieve work objectives.	4.14	0.87	0.76			
	B5	My manager often encourages colleagues in self-growth.	2.57	0.85	0.71			
	B7	When I feel ignored, my manager will express timely concern.	3.29	0.88	0.77			
	B8	When I complete the mission, my manager will offer timely appreciation.	2.88	0.85	0.72			
	B9	My manager is willing to spend time in instructing my work.	2.43	0.82	0.68			
Organizational innovation	E1	All units within the company coordinate well with one another.	2.19	0.81	0.65	0.95	0.73	0.94
	E3	My company allows freedom of expression, and opinions are permitted on different levels of a task.	2.74	0.85	0.72			
	E4	My company highly values research and the development of new and advanced technologies.	2.93	0.84	0.70			
	E5	My company has partners across different departments and companies, which inspires thinking in different directions.	3.95	0.89	0.80			
	E6	One is allowed to propose plans of revision of internal work process to facilitate cooperation among colleagues.	3.48	0.88	0.77			
	E9	One can discuss an issue in full detail and offer criticism freely.	3.56	0.87	0.77			
	E10	The employees are motivated and passionate about work and are able to influence the team environment.	3.03	0.85	0.73			
Organizational culture	C1	My company is similar to a big family where people share work and life together.	2.88	0.86	0.75	0.92	0.71	0.90
	C2	The executives in my company behave as mentors or parents.	3.28	0.90	0.80			
	C3	My company emphasizes the importance of teamwork.	2.52	0.85	0.73			
	C4	My colleagues are willing to innovate and take risks.	2.18	0.84	0.71			

Table 3. *Cont.*

Construct		Item	VIF	Outer Loading	SMC	CR	AVE	Cronbach's Alpha
Customer service	F1	Customers are highly satisfied with my company.	3.20	0.89	0.80	0.92	0.70	0.89
	F2	My company emphasizes greatly the quality of services for clients.	2.05	0.77	0.59			
	F5	Employees are all able to grasp the demands of the clients.	3.05	0.89	0.79			
	F6	Colleagues in my company are often able to take the initiative to interact with external personnel.	2.42	0.84	0.71			
	F7	Colleagues in my company are good at establishing long-term relationships with clients.	1.84	0.78	0.61			
Knowledge integration capability	D1	My company has a fair evaluation system.	3.03	0.86	0.73	0.94	0.70	0.88
	D2	The direction of the development of my company is the same as that of the employees.	2.70	0.84	0.71			
	D4	There is no rigid bureaucracy in my company, and flexible changes in the rules are allowed.	2.33	0.79	0.63			
	D5	There is an unblocked channel of promotion.	3.22	0.86	0.74			
	D6	There is an assessment mechanism with clear rewards and punishments in my company.	2.87	0.85	0.72			
	D8	Specific methods are taken to encourage employees to bravely voice different opinions or beliefs.	2.83	0.83	0.69			
	D9	Research on new ideas will be given additional rewards in my company.	2.97	0.82	0.67			
Knowledge absorptivity	H1	The internal system of my company is highly informatized.	2.08	0.83	0.69	0.92	0.69	0.93
	H2	My company will actively incorporate new technologies or new techniques.	2.85	0.86	0.75			
	H3	My colleagues are used to discussing new concepts.	3.15	0.89	0.79			
	H5	There is a specific department or personnel in charge of collecting relevant information on Industry 4.0 in my company.	1.67	0.70	0.49			
	H7	My company has a specific way of making information open and transparent.	2.34	0.84	0.71			

For the convergent validity analysis, we looked at CR and AVE, as suggested in Fornell and Larcker [114]. Table 3 shows that the CR values are between 0.92 and 0.95, which is higher than the recommended 0.7 threshold in Esposito, Vinzi, Chin, Henseler, and Wang [115]. This means a satisfactory level of internal consistency. Furthermore, using

the AVE of the latent variables, we calculated the variation explanatory power of each measured variables on the latent variables. In Table 3, the AVE value of each latent variable is between 0.69 and 0.74, which is higher than the standard of 0.5 in Bagozzi and Yi [109], indicating good discriminant validity and convergent validity in our model.

We discussed the correlations between factors and variables based on their cross-loadings. The cross-loadings of the factors for each construct are over 0.50 and are statistically significant. Considering the structural model, the standardized path coefficients are all statistically significant, and the own-loadings of each construct are larger than the cross-loadings. This shows that our measurements have considerably good convergent validity and discriminant validity, as demonstrated in Table 4.

Table 4. Cross-loadings of factors.

Construct	Item		Leadership Style	Organizational Innovation	Organizational Culture	Customer Services	Knowledge Integration Capability	Knowledge Absorptiv-ity
Leadership Style	B2	I respect my manager's management style.	0.884	0.587	0.689	0.524	0.623	0.470
	B4	My manager is able to motivate my team and me to achieve work objectives.	0.870	0.561	0.698	0.521	0.596	0.467
	B5	My manager often encourages colleagues in self-growth.	0.845	0.543	0.683	0.447	0.535	0.470
	B7	When I feel ignored, my manager will express timely concern.	0.879	0.626	0.677	0.540	0.620	0.542
	B8	When I complete the mission, my manager will offer timely appreciation.	0.847	0.561	0.640	0.486	0.525	0.485
	B9	My manager is willing to spend time in instructing my work.	0.823	0.487	0.566	0.466	0.497	0.449
Organizational Innovation	E1	All units within the company coordinate well with one another.	0.625	0.807	0.691	0.624	0.755	0.634
	E3	My company allows freedom of expression, and opinions are permitted on different levels of a task.	0.523	0.847	0.601	0.638	0.714	0.624
	E4	My company highly values research and development of new and advanced technologies.	0.499	0.836	0.610	0.651	0.661	0.661
	E5	My company has partners across different departments and companies, which inspires thinking in different directions.	0.555	0.895	0.653	0.697	0.708	0.746
	E6	One is allowed to propose plans of revision of internal work process to facilitate cooperation among colleagues.	0.595	0.879	0.710	0.674	0.701	0.690
	E9	One can discuss an issue in full detail and offer criticism freely.	0.533	0.875	0.635	0.701	0.704	0.675
	E10	The employees are motivated and passionate about work and are able to influence the team environment.	0.591	0.853	0.710	0.770	0.746	0.720
Organizational Culture	C1	My company is similar to a big family where people share work and life together.	0.687	0.651	0.863	0.640	0.661	0.582
	C2	The executives in my company behave as mentors or parents.	0.721	0.691	0.896	0.634	0.686	0.582
	C3	My company emphasizes the importance of teamwork.	0.612	0.615	0.854	0.600	0.573	0.477
	C4	My colleagues are willing to innovate and take risks.	0.653	0.707	0.840	0.631	0.680	0.661

Table 4. *Cont.*

Construct	Item		Leadership Style	Organizational Innovation	Organizational Culture	Customer Services	Knowledge Integration Capability	Knowledge Absorptiv-ity
Customer Services	F1	Customers are highly satisfied with my company.	0.496	0.741	0.650	0.894	0.705	0.689
	F2	My company emphasizes greatly the quality of services for clients.	0.402	0.568	0.547	0.769	0.480	0.545
	F5	Employees are all able to grasp the demands of the clients.	0.556	0.687	0.657	0.887	0.685	0.652
	F6	Colleagues in my company are often able to take the initiative to interact with external personnel.	0.484	0.704	0.645	0.844	0.651	0.699
	F7	Colleagues in my company are good at establishing long-term relationships with clients.	0.485	0.610	0.606	0.780	0.593	0.581
Knowledge Integration Capability	D1	My company has a fair evaluation system.	0.597	0.665	0.668	0.701	0.856	0.581
	D2	The direction of the development of my company is the same as that of the employees.	0.610	0.710	0.726	0.674	0.840	0.633
	D4	There is no rigid bureaucracy in my company, and flexible changes in the rules are allowed.	0.537	0.723	0.611	0.634	0.792	0.559
	D5	There is an unblocked channel of promotion.	0.542	0.702	0.609	0.602	0.858	0.593
	D6	There is an assessment mechanism with clear rewards and punishments in my company.	0.557	0.663	0.633	0.587	0.848	0.590
	D8	Specific methods are taken to encourage employees to bravely voice different opinions or beliefs.	0.551	0.706	0.655	0.617	0.828	0.632
	D9	Research on new ideas will be given additional rewards in my company.	0.453	0.700	0.568	0.552	0.817	0.611
Knowledge Absorptivity	H1	The internal system of my company is highly informatized.	0.438	0.607	0.578	0.634	0.558	0.828
	H2	My company will actively incorporate new technologies or new techniques.	0.480	0.732	0.616	0.704	0.632	0.865
	H3	My colleagues are used to discussing new concepts.	0.556	0.770	0.649	0.722	0.668	0.891
	H5	There is a specific department or personnel in charge of collecting relevant information on Industry 4.0 in my company.	0.297	0.467	0.386	0.430	0.462	0.702
	H7	My company has a specific way of making information open and transparent.	0.507	0.661	0.564	0.604	0.632	0.841

Although cross-loadings have been widely applied to evaluate the discriminant validity of PLS-SEM, Henseler, Ringle, and Sarstedt [116] contend that to increase sensitivity, HTMT indicators should be adopted to examine such validity across constructs. As shown in Table 5, the HTMT value for each variable is below 0.9, representing a fair level of discriminant validity across the constructs [117,118].

Table 5. Heterotrait–monotrait ratio (HTMT).

	Knowledge Absorptivity	Organizational Innovation	Organizational Culture	Knowledge Integration Capability	Leadership Style	Customer Orientation
Knowledge absorptivity	-	-	-	-	-	-
Organizational innovation	0.893	-	-	-	-	-
Organizational culture	0.837	0.836	-	-	-	-
Knowledge integration capability	0.788	0.857	0.755	-	-	-
Leadership style	0.707	0.698	0.838	0.606	-	-
Customer orientation	0.817	0.864	0.831	0.839	0.636	-

4.2.2. Evaluation of the Structural Model

We calculated the coefficient of determination (R^2) and Cohen's f^2 (f^2) to study the overall explanatory power and model fit of the overall model [119,120]. The higher the R^2 value, the higher the explanatory power of a model [111]. Within this study's context, the standard value should be above 0.5. In our study, the R^2 of knowledge absorptivity and KIC on organizational culture is 0.628, while the R^2 of leadership style, organizational culture, and customer orientation on organizational innovation is 0.714. The results indicate that the explanatory power of the endogenous latent variables is above 0.5 in the model (see Figure 3), and that our model is robust and stable. Furthermore, Cohen's f^2 can be used to assess the significance of the explanatory power of exogenous variables on endogenous variables. In our case, the f^2 values for knowledge absorptivity on organizational culture (0.422) and for customer orientation on organizational innovation (0.382) both fall into the category of a large effect ($f^2 > 0.35$), according to Cohen [121].

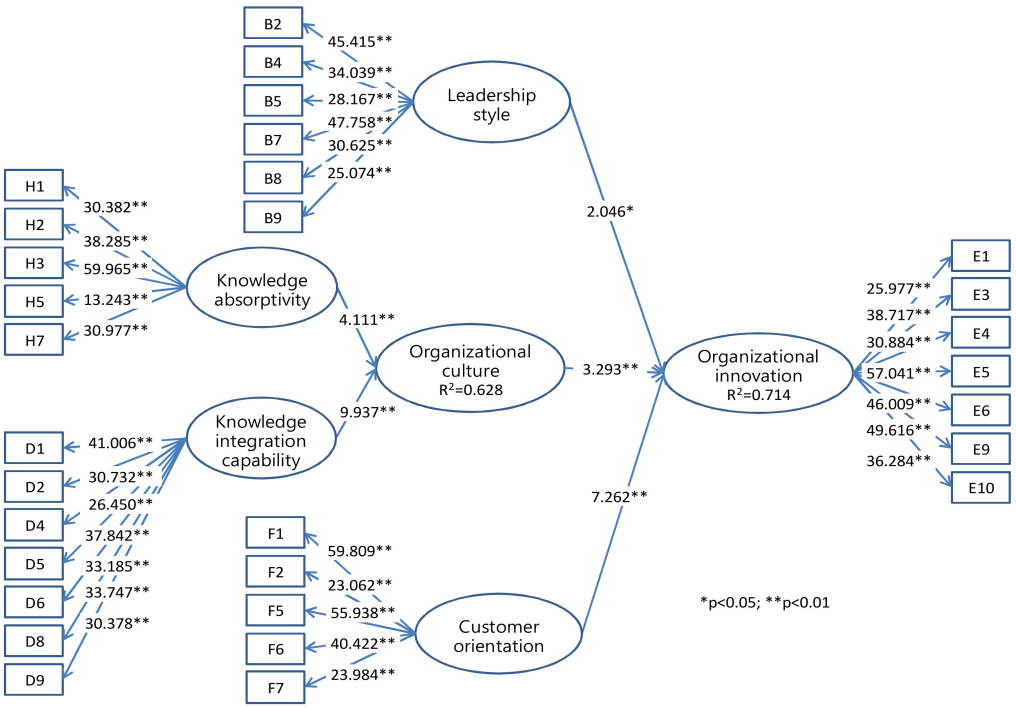

Figure 3. Bootstrapping results.

Regarding the model fitness, we studied the standardized root mean square residual (SRMR) and normed-fit index (NFI) as indicators. In Table 6, the SRMR is 0.057, which is lower than 0.08, showing an acceptable fit [122]. Meanwhile, the NFI is 0.805, which is greater than 0.8, indicating an acceptable model fit [123]. Overall, we believe that our model has a good model fit.

Table 6. Model fitness of our research model.

Fit Indices	Research Model	Allowable Standard	Reference
SRMR	0.057	<0.08	Hu and Bentler [124]
NFI	0.805	>0.8	Ullman et al. [123], Bearden, Sharma, and Teel [125]

Note: SRMR = standardized root mean square residual; NFI = normed-fit index.

4.3. Description of Hypothesis Testing

We employed the bootstrap method to test the hypotheses. Bootstrapping estimates the population based on the observed samples and then produces estimations of interest by re-sampling the estimated population. In most cases, the approximation from bootstrapping is more accurate than the common limit approximation. The advantage is that bootstrapping can modify the constraints that the research model does not conform to a normal distribution, thus obtaining more accurate estimations [126]. With 250 valid samples, and according to Hair, Ringle, and Sarstedt [113], 5000 samples are required for stable results. That is, 5000 times of re-sampling can help examine the PLS model better.

In the PLS model, the factor loading of knowledge absorptivity on organizational culture (H2a) is 0.275, or lower than 0.50, which is not statistically significant (see Figure 2). However, after 5000 times of bootstrapping, the t-value of the effect of knowledge absorptivity on organizational culture reaches 4.111, and it is significant at the 1% level ($p < 0.01$) (see Figure 3). Therefore, we adopted bootstrapping to reevaluate the path relations among different constructs. The results are shown in Table 7. It is evident that four out of the five hypotheses (H2, H3, H2a, and H2b) are significant at the 1% level ($p < 0.01$), while H1 is significant at the 5% level ($p < 0.05$). This indicates that the bootstrapping results support all hypotheses. Furthermore, KIC has a relatively large effect on organizational culture, while organizational innovation is influenced by customer orientation, organizational culture, and leadership style, in descending order in terms of their effects (see Table 7).

Table 7. Results of hypothesis testing.

Hypothesis	Path Relations	Path Value	Result
H2a	Knowledge absorptivity → Organizational culture	4.111 **	Valid
H2b	Knowledge integration capability → Organizational culture	9.937 **	Valid
H1	Leadership style → Organizational innovation	2.046 *	Valid
H2	Organizational culture → Organizational innovation	3.293 **	Valid
H3	Customer orientation → Organizational innovation	7.262 **	Valid

*: $p < 0.05$. **: $p < 0.01$.

5. Conclusions

As the implementation of Industry 4.0 involves leadership styles, customer perspectives, and the application of knowledge, organizational culture and organizational innovation will change as a result, with implications for corporate sustainability. Although leadership style, customer orientation, and organizational culture have all been categorized as organizational innovation factors that affect corporate sustainability, previous research has not examined the interactions between these factors when promoting Industry 4.0. In order to fill the research gap, this study proposes a research model that covers these constructs. The results of this study confirm the important role of organizational culture and knowledge integration capabilities in the industry. Using the above-mentioned methods,

we studied the characteristics of organizational innovation and proposed a model of its determinants. Here, we present the following conclusion with empirical evidence from the structural equation modeling.

5.1. Customer Orientation Is the Most Important Factor for Organizational Innovation

According to our experimental results, leadership style, organizational culture, and customer orientation can shape organizational innovation. The value of the path relations for customer orientation is the highest (7.262 **, $p < 0.01$), highlighting it as the most important factor for organizational innovation. This is followed by leadership style (3.293 **, $p < 0.01$) and organizational culture (2.046 **, $p < 0.01$). The empirical evidence suggests that when popular leaders face demand from external customers, compared to engaging in innovation activities or when employees initiate such activities, companies can be prompted to formulate corresponding measures. Subsequently, this will promote organizational innovation.

5.2. Knowledge Integration Capability Can Affect Organizational Innovation through Organizational Culture

Our study suggests that there are effects of KIC and knowledge absorptivity on organizational culture, and that both indirectly affect organizational innovation through organizational culture. The KIC of individual employees tends to influence organizational culture. However, KIC does not directly affect organizational innovation. Rather, it first affects organizational culture together with factors such as knowledge absorptivity. Then, organizational culture affects organizational innovation. Compared to knowledge absorptivity, the data reveal that the path relationship is the strongest between KIC and organizational innovation. This suggests the important role of employee's KIC on organizational innovation. Meanwhile, it can be inferred that with a stronger knowledge integration capability among employees, the more likely it is that individuals can positively affect the level of innovation of a company. If employees are strongly capable of knowledge integration, they can promote organizational innovation by influencing organizational culture. Meanwhile, as knowledge absorptivity requires the collection of group insights, it does not exert the same effect on organizational innovation via organizational culture as KIC. In other words, if an organization aims to maintain momentum for innovation, it is advisable to employ individuals with a strong KIC.

5.3. Contribution of This Study

Many companies are investing heavily in technology, data security, and worker skills in the promotion of Industry 4.0, but the return on investment remains uncertain [19] (Kiel, Müller, Arnold, and Voigt, 2017). Nevertheless, Industry 4.0 inevitably remains the direction of transformation for manufacturing industries that compete successfully in the global market. This study can help companies understand the approach to organizational innovation in promoting Industry 4.0 for sustainable operations and the factors that can influence it. Therefore, the results of this study may be useful for future business operators interested in promoting sustainability. The managerial implications of this study for companies promoting Industry 4.0 for sustainability are that business leaders can continue to promote organizational innovation, but they must continue to do so based on customer orientation, and any changes that come through leadership style or internal organizational culture will not match the expectations of customers. In addition, in SMEs (Small and Mid-size Enterprises), the development of the company depends on the founders or owners, who are often also managers and therefore have the responsibility to shape an open organizational culture [12]. The larger the company, the more formal and complex the organizational structure, and thus the more difficult it is to communicate within the organization. Therefore, the larger the enterprise, the higher the requirement to establish an efficient organizational culture. However, in the era of Industry 4.0, enterprises have to face a large amount of data and knowledge generated, and they must strengthen the ability of knowledge integration, rather than just absorbing and archiving a large amount.

For enterprises, the integrated knowledge will first change the organizational culture, and then lead to organizational innovation, thus making the enterprise sustainable.

5.4. Limitations and Recommendations

This study is a cross-sectional study of the survey for a specific period (December 12, 2018 to March 4, 2019), which has spanned three months and lacks data collected over a longer period of time. However, with the passage of time and changes in industries, how employees would think of Industrial 4.0 and organizational innovation might shift under the influence of the existing external conditions. Therefore, we recommend that future research can consider case studies or incorporate long-term longitudinal studies to examine in detail the impact of each construct on organizational innovation. In terms of the selection of subjects, we have attempted to achieve a balance in the variety of respondents, from senior supervisors, middle-level supervisors, to general personnel. Meanwhile, we have also included employees specializing in different work, including administration, research and development, engineering, business, and so forth. Scholars are advised to compare the individual opinions of employees of different positions and competence levels.

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