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Leadership for Sustainable Growth of High-tech Enterprises in Guangxi Province

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Abstract

Background and Aim: China's economy has experienced 30 years of rapid development, and its development has evolved from a crude model to a new high-quality model. High-tech enterprises have become an important engine for promoting China's economic development. This study aims to study the leadership abilities required, leadership affect factors, and finally propose a specific leadership model to promote the sustainable development of high-tech enterprises.

Materials and Methods: The research methodology adopted the Ethnographic Delphi Future Research (EDFR) technique using 17 experts who are the CTO or CEO in high-tech enterprises.

Results: The research results give a CTO leadership model also help explore a way to promote the development of high-tech industries through the efforts of enterprises themselves, to realize China's modernization. The result reveals that 1. CTOs in high-tech enterprises should possess: Technical leadership and strategic thinking; Collaboration and team building; Adaptability and Resilience; and Innovation and R&D. 2. Sustainable development strategies that high-tech enterprises need to possess are Environmental Sustainability Initiative; Social Responsibility and Ethical Practice; and Economic sustainability and long-term viability. 3. CTO Strategies for Improving the Sustainable Growth of High-tech Enterprises include Key Steps to Making the Most of Emerging Technologies; Key Steps to getting the most out of data analysis and decision-making; Strategies for overcoming corporate resistance to sustainable reforms; and Strategies for managing stakeholder expectations. 4. Prediction of CTO's Future Role are: Focus on digital transformation; Data-driven decision-making; Leading position in cybersecurity; Sustainability and ethical technology adoption; Customer-centric innovation; Agility and flexibility; Collaboration with senior executives; Talent management and skill enhancement skills; Emphasize the innovation ecosystem; and Addressing Regulatory Challenges

Conclusion: The CTO leadership model explores a way to promote the development of high-tech industries through the efforts of enterprises as 1) CTOs in high-tech enterprises 2) Sustainable development strategies 3) CTO Strategies for Improving Sustainable Growth of High-tech Enterprises and 4) Prediction of CTO's Future Role.

Keywords: CTO; High-tech Enterprises; Leadership Model; Delphi; Sustainable Growth

Introduction

China's economy has experienced 30 years of rapid development, and its development model has evolved from a crude model to a new normal of high-quality models. High-tech enterprises are the main force for high-quality development. High-tech enterprises have become an important engine for promoting China's economic development. There were 1,203 high-tech companies listed in China in 2020, and 1,059 companies received financial subsidies that year, accounting for 88.02% (Yuan, 2022). According to Torch statistics, among the industrial enterprises above the designated size in Guangxi, high-tech enterprises only account for 17%, but they contribute about 40% of the total operating income, about 30% of the total industrial output value, and about 30% of the total profit to the local economy.

The biggest challenge faced by enterprises after COVID-19 is the lack of leaders with higher leadership. Every enterprise needs those leaders with higher leadership to achieve its goals.

The greatest role of a leader in an enterprise is to give play to his leadership. Leaders play an important role in upgrading the quality of service of businesses and encouraging employees to reach their full potential (Safitri et al., 2022). Leadership, credibility, and innovation are related to work efficiency (Ma Zheyao & Supit Boonlab 2023). The degree of enthusiasm of the management directly affects the development and profitability of the enterprise. In the management team, the Chief Technology Officer (CTO), as the top manager of the technology system and the most important human capital, plays a key role

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in the process of enterprise innovation. Lewis (1990) believes that the chief technology officer (CTO) is not a laboratory leader transformed into a civilian employee, but a technical businessperson who can be deeply involved in the company's overall strategy. Zhang (2018) believes that American CTOs need to have forward-looking strategic thinking and focus on grasping the technological development direction of products and services, while Chinese CTOs prefer R&D management.

In terms of leadership, Northouse (2021), believes that "influence is a part of leadership, manifested as influence mechanism on followers. Leadership must exert influence on the actor's behavioral decision-making, otherwise, there would be no so-called leadership (Zhang et al, 2011). Grundy (2006) believes that sustainable leadership refers to the leader's ability in strategic harmonious and scientific development such as stimulating innovation, improving efficiency, and overall planning, and proposed a concept chain and five factors that constitute leadership: influence, control, decisiveness, foresight, and charisma.

The main purpose of this research is to study the leadership abilities required and leadership factors for high-tech enterprises' sustainable development, and finally propose a specific leadership model. The study adopted the EDFR (Ethnographic Delphi Future Research) prospective research method, which requires 17 experts' consensus opinions. (Macmillan, 1971). After three rounds of expert consultation, feedback, and modifications, the leadership model was finally determined. The results of this study aimed to establish sustainable development through ideas for promoting them through the efforts of enterprise business leaders themselves.

Globally, there is increasing attention on sustainable development, and China, as one of the main drivers of economic growth, relies heavily on its high-tech enterprises for development. However, in recent years, challenges such as reduced government subsidies due to COVID-19 and the US-China trade war have emerged. Thus, this study aims to explore methods of promoting the sustainable development of high-tech enterprises in Guangxi Province through leadership training and technological innovation.

Give the reason to present this paper

The rationale for presenting this paper is to address the critical need for sustainable development strategies in the context of challenges faced by high-tech enterprises, particularly in Guangxi Province. By exploring the role of leadership training and technological innovation in fostering sustainable growth, this paper seeks to offer practical insights and solutions to enhance the resilience and competitiveness of high-tech industries in the face of evolving economic and environmental dynamics.

Objectives

To study the leadership abilities required, leadership affect factors and finally propose a specific leadership model to promote the sustainable development of high-tech enterprises.

Literature Review

Past research indicates that leadership training has significant impacts on organizational performance and employee development. According to a study in the Harvard Business Review, effective leadership training can enhance employee job satisfaction and performance, thereby strengthening organizational competitive advantage (Goleman, 2000). Furthermore, numerous studies emphasize the importance of technological innovation for business development. For instance, research conducted at the Massachusetts Institute of Technology (MIT) found that technological innovation is a key driver of enterprise competitiveness and long-term growth (Brynjolfsson & McAfee, 2014).

Moreover, the combination of leadership and technological innovation is particularly crucial for high-tech industries. Studies suggest that the abilities of leaders are essential for the innovation and competitiveness of high-tech enterprises. For example, research at Stanford University indicates that exceptional leaders can inspire team members to generate new ideas and solutions, thus driving technological innovation (Davenport & Harris, 2007). Therefore, leadership training is critical for enhancing the innovation capability and market competitiveness of high-tech enterprises.

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In summary, past research underscores the importance of leadership training and technological innovation for organizational performance and competitive advantage. This paper will explore how leadership training and technological innovation can facilitate the sustainable growth of high-tech enterprises in Guangxi Province, building upon this foundation.

Methodology

Data Source: The researcher requested cooperation and contacted the experts about the research by themselves to ask about each expert's willingness to answer the questionnaire. The number of experts was 17 people in the following ways:

Instrument: The tools used in this research are mainly three versions of questionnaires developed based on The Delphi Technique:

The first version is a semi-open interview with experts.

The second version is a five-level estimation scale.

The third version is a five-level scale questionnaire, and its rating level is each expert from the second round of questionnaires.

Data Collecting Process: The researcher requested cooperation and contacted the experts about the research by themselves to ask about each expert's willingness to answer the questionnaire. The number of experts was 17 people in the following ways: For the 1st,2nd, and 3rd questionnaires, the researcher brought the interview form and the questionnaire to experts to answer. and get it back Self-answering every round of questionnaires The researcher submitted questionnaires in the 1st, 2nd, and 3rd rounds for 17 people, totaling 6 months of data collection (March 2023– September 2023)

Data Analysis: The data analysis from the questionnaire (Delphi Technique) for the 2nd and 3rd time was used to analyze data. Research Statistics mainly involves descriptive statistical analysis and expert consultation reliability analysis

Results

The results of data on leadership for sustainable growth of high-tech enterprises in Guangxi Province after three rounds of expert consultation are shown in Table 1.

From Table 1, it was found that:

Technical leadership and strategic thinking, high digits (usually 5) show an emphasis on long-term planning, a customer-centric approach, and gaining a competitive advantage. A low IQR (0.5 or 1) indicates a high level of agreement and consensus on these competencies. This means that the industry generally believes that these capabilities are crucial to the success of CTOs, and their evaluations are relatively consistent with few differences.

Table 1 CTOs in high-tech enterprises should possess. (Section 1)

No	Item	Mdn	MO	IQR	Seq
	Adaptability and resilience in high-tech environments				
1	Dynamic technology landscape (closely following technology hotspots)	5	5	1	1
2	Agile decision-making	5	5	1	1
3	Embrace subversion	5	5	0.5	1
4	Navigation uncertainty (overcoming uncertainty)	5	5	1.5	1
5	Rotation strategy	5	5	1	1
6	Experimentation and Innovation	5	5	1	1
7	Resolve failed issues	5	5	1	1
8	Technical Implementation Challenges	5	5	1	1

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No	Item	Mdn	MO	IQR	Seq
9	Talent retention and development	5	5	1	1
10	Continuous learning	5	5	0.5	1
11	Dealing with market fluctuations	4	5	1	11
12	Leading through change	4	4	1	11
	Addressing regulatory and compliance challenges				
13	Ensure safety and compliance	5	5	1	1
14	Comply with industry standards and regulations	5	5	1	1
15	Addressing data privacy and security issues	4	4	1	3
	Business acumen and strategic thinking				
16	Understand business objectives	5	5	1	1
17	Market awareness	5	5	1	1
18	Reduce risk	5	5	1	1
19	Innovation consistency	5	5	0.5	1
20	Long term planning	5	5	1	1
21	A customer-centric approach	5	5	1	1
22	competitive edge	5	5	1	1
23	Driving Technology Strategy	4	4	1	8
24	decision-making	4	4	1	8
25	financial management	4	4	1	8
26	Value creation	4	5	1	8
27	Cross-functional collaboration	4	4	1	8
28	Opportunity assessment	4	4	1	8
29	performance evaluation	4	4	1	8
	Collaboration and team building				
30	Cross-functional collaboration	5	5	1	1
31	Collaboration with the technical team	5	5	1	1
32	Effective communication	5	5	0.5	1
33	Establish a high-performance team	5	5	0.5	1
34	Encourage team innovation	5	5	1	1
35	Authorize team members	5	5	0.5	1
36	Guidance and professional development	5	5	1	1
37	Conflict team resolution	5	5	1	1
38	Ensure team diversity and inclusivity	5	5	1	1
39	Encourage open communication within the team	5	5	1	1
40	Commending achievements	5	5	1	1
41	Promoting knowledge sharing	5	5	0	1
42	Adaptive leadership	4	5	1	13
	Cultivate innovation and research and development				
43	Ability to obtain information	5	5	0.5	1
44	Inferential innovation ability	5	5	1	1
45	Project risk identification and control capabilities	5	5	1	1
46	Research decision-making ability	5	5	1	1
47	Experimental observation ability	5	5	1	1
48	Creating an Innovative Culture	5	5	1	1
49	Manage intellectual property and patent	5	5	0.5	1
50	Integrating business-oriented R&D research	5	5	0.5	1

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No	Item	Mdn	MO	IQR	Seq
	Technical expertise and vision				
51	Evaluate emerging technologies	5	5	1	1
52	Addressing technical challenges	5	5	1	1
53	Promoting innovation	5	5	0	1
54	Harnessing complex technological environments	4	4	1	5
55	Evaluate emerging technologies	5	5	1	1

In collaboration and team building, the median across all projects is generally 5, and the IQR is usually 0.5 or 1, indicating a high level of consistency and strong consensus. This emphasizes the importance of cross-functional collaboration, effective communication, building high-performing teams, promoting team innovation, and ensuring team diversity and inclusion. These findings highlight the critical role the CTO plays in fostering team collaboration and driving team success.

Adaptability and Resilience, in terms of adapting to the changes and challenges of high-tech environments, the median is generally 5 and the IQR is 1 or slightly higher, reflecting that while there is a degree of diversity of views, there is a general belief that these capabilities are very important. This includes agile decision-making, embracing disruption, navigating uncertainty, experimentation, and innovation, and more. This suggests that, although views on how best to achieve these goals may differ, there is broad agreement on the importance of the capabilities themselves.

For innovation and R&D, the median continues to be 5 and the IQR is generally low (0.5 or 1), indicating strong consensus on capabilities such as access to information, reasoning about innovation, project risk identification and control, and research decision-making capabilities. This reflects the importance of continuous innovation and effective R&D to remain competitive in a rapidly evolving technological environment.

Overall, the data underscores the multifaceted role of CTOs in high-tech enterprises, encompassing technical expertise, strategic thinking, collaboration, adaptability, innovation, and regulatory compliance. These findings can inform organizations in defining expectations for CTO roles and developing strategies to support their success.

Table 2 Sustainable development strategies that high-tech enterprises need to possess. (Section 2)

No	Item	Mdn	MO	IQR	Seq
	Economic sustainability and long-term feasibility				
56	Business Model Assessment	5	5	1	1
57	Financial planning and budgeting	5	5	1	1
58	Profitability and cost control	5	5	1	1
59	Market analysis and trends	5	5	1	1
60	Diversification of income streams	5	5	1	1
61	risk management	5	5	1	1
62	Long-term innovation investment	5	5	0	1
63	Agility and adaptability	5	5	0.5	1
64	Strategic Partnership	5	5	1	1
65	Talent management and retention	5	5	0.5	1
66	Environmental and Social Responsibility	4	4	1	11
67	Continuous monitoring and evaluation	4	4	1	11
	Environmental Sustainability Initiative				
68	Paperless Initiative	5	5	1	1
69	energy efficiency	4	4	1	2
70	renewable energy	4	4	1	2

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No	Item	Mdn	MO	IQR	Seq
71	Green IT procurement	4	4	1	2
72	Circular Economy Practice	4	4	1	2
73	Virtualization and Cloud Computing	4	4	0.5	2
74	Carbon footprint tracking	4	4	1	2
75	Sustainable software development	4	4	1	2
76	Remote work and remote work	4	4	0	2
77	Employee Education and Participation	4	4	1	2
78	Green Data Center	4	4	1	2
79	Green Building and Facility Management	4	4	1	2
80	Environmental certification	4	4	1	2
	Social Responsibility and Moral Practice				
81	Environmental sustainability	5	5	1	1
82	Responsible innovation	5	5	1	1
83	Corporate Social Responsibility (CSR) Strategy	4	4	1	3
84	Ethical Technology Use	4	4	1	3
85	Inclusive design	4	4	1	3
86	diversity and inclusion	4	4	1	3
87	Ethical supply chain	4	4	1	3
88	transparency and accountability	4	5	1	3
89	Ethical artificial intelligence and data ethics	4	4	1	3
	Social Responsibility and Moral Practice (Continue)				
90	Ethical standards and code of conduct	4	4	1	3
91	Human rights and labor practices	4	4	1	3
92	Stakeholder engagement	4	4	1	3

From Table 2, there are three main areas: environmental sustainability initiatives, social responsibility and ethical practices, and economic sustainability and long-term viability. For these elements, the median (Mdn) and interquartile range (IQR) provide insight into their importance and degree of consistency.

Environmental Sustainability Initiative: Key elements are energy efficiency, renewable energy, green IT procurement, circular economy practices, virtualization and cloud computing, carbon footprint tracking, sustainable software development, remote working, paperless initiatives, employee education and engagement, green data centers, green Building and facilities management, environmental certification. Most items have a median of 4, suggesting that they are generally considered important. Paperless initiatives have a median of 5, indicating higher importance. Most items have an IQR of 1, indicating some degree of consistency in their importance, while telework and telecommuting have an IQR of 0, indicating extremely high consistency in their importance.

Social Responsibility and Ethical Practice: Key elements are corporate social responsibility (CSR) strategy, ethical use of technology, inclusive design, environmental sustainability, diversity and inclusion, ethical supply chain, responsible innovation, transparency and accountability, ethical AI and data ethics, ethical standards and codes of conduct, human rights and labor practices, stakeholder engagement. Most items in this category have a median of 4, indicating that they are considered important. Environmental sustainability and responsible innovation had a median of 5, suggesting their particular importance in social responsibility and ethical practices. Most items have an IQR of 1, indicating a high degree of consistency.

Economic sustainability and long-term viability: Key elements are Business model assessment, financial planning and budgeting, profitability, and cost control, market analysis and trends, revenue diversification, risk management, long-term investment in innovation, flexibility, and adaptability, strategic

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partners, talent management and retention, environment and social responsibility, continuous monitoring, and evaluation. The median for all projects in this category is 5, except for Environmental and Social Responsibility and Continuous Monitoring and Evaluation, which is 4. This reflects the widespread view that economic sustainability and long-term viability are critical among high-tech businesses. Most items have an IQR of 1, indicating a relatively consistent assessment of their importance. Long-term investment in innovation, flexibility, adaptability, and talent management and retention have lower IQRs (0 to 0.5), indicating greater consistency in their importance.

These data points reveal the core focus of high-tech companies' sustainability strategies, with environmental initiatives, social responsibility, and economic sustainability being key to their success. The use of medians and IQRs not only reveals the degree to which these elements are generally recognized but also provides insight into the industry's perception of the consistency of these strategies. Particularly, paperless initiatives, environmental sustainability, and responsible innovation show higher importance within their corresponding areas, while long-term investment in innovation, flexibility and adaptability, talent management, and retention is higher in the economic sustainability aspect is particularly critical.

Table 3 CTO Strategies for Improving Sustainable Growth of High-tech Enterprises.

No	Item	Mdn	MO	IQR	Seq
Key steps to fully utilize data analysis and decision-making					
93	Predictive analysis for prediction	5	5	0.5	1
94	Real-time analysis of agility	5	5	1	1
95	Continuous improvement	5	5	0.5	1
96	Visualization and Communication	4	4	1	4
97	Ethical considerations	4	4	1	4
Key steps to fully utilize emerging technologies					
98	Technical Landscape Analysis	5	5	0	1
99	Strategic coordination	5	5	0.5	1
100	Innovative mindset	5	5	0.5	1
101	pilot project	5	5	0.5	1
102	Talent acquisition and development	5	5	1	1
103	Risk and Security Management	5	5	1	1
104	Technical roadmap	5	5	1	1
105	User-centric approach	5	5	1	1
106	Continuous evaluation and improvement	5	5	0	1
107	Collaboration and Partnership	4	4	1	10
108	Data-driven decision-making	4	4	1	10
109	Scalability and flexibility	4	5	1	10
110	Regulatory compliance	4	4	1	10
Strategies for managing stakeholder expectations					
111	Open and transparent communication	5	5	0	1
112	Actively listening	5	5	0.5	1
113	Set realistic expectations	5	5	0	1
114	Establish clear goals and objectives	5	5	0.5	1
115	Engage stakeholders as early as possible	5	5	1	1
116	Provide demonstrations and progress reports	5	5	1	1
117	Continuous engagement	5	5	1	1
118	Celebrate achievements	5	5	1	1
119	Manage risks and issues	4	4	1	9
120	Building trust and credibility	4	4	1	9

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No	Item	Mdn	MO	IQR	Seq
121	Resolve conflicts and differences of opinion	4	4	1	9
Strategies to overcome the resistance to sustainable reform in enterprises					
122	effective communication	5	5	1	1
123	Provide training and support	5	5	1	1
124	Lead by example	5	5	1	1
125	Monitoring and adjustment	5	5	1	1
126	Early engagement with stakeholders	4	4	1	5
127	Create a shared vision	4	4	1	5
128	Authorize change agents	4	4	1	5
129	Addressing Fear and Uncertainty	4	4	1	5
130	Celebrate Rapid Victory	4	5	1	5
131	Break down changes into manageable steps	4	4	1	5

From Table 3, it was found that:

Key Steps to Making the Most of Emerging Technologies: Projects include technology landscape analysis, strategic alignment, innovative thinking, pilot projects, collaborations and partnerships, data-driven decision-making, talent acquisition and development, risk and security management, scalability and flexibility, regulatory compliance, technology roadmaps, user-based Centered approach, continuous evaluation, and improvement with Median range of 4-5 and interquartile range: 0-1

Key steps to getting the most out of data analysis and decision-making: Projects include visualization and communication, predictive analytics, real-time agile analytics, ethical considerations, and continuous improvement with a median range of 4-5 and interquartile range of 0.5-1

Strategies for overcoming corporate resistance to sustainable reforms. Projects include effective communication, early engagement with stakeholders, creating a shared vision, empowering change agents, providing training and support, addressing fear and uncertainty, celebrating wins quickly, breaking change into manageable steps, leading by example, monitoring and adjustments with a median range of 4-5 and interquartile range of 1.

Strategies for managing stakeholder expectations: Projects include open and transparent communication, active listening, setting realistic expectations, establishing clear goals and objectives, engaging stakeholders early, delivering demonstrations and progress reports, risk, and issue management, building trust and credibility, resolving conflicts and differences of opinion, continue to engage, and celebrate achievements with median range of 4-5 and interquartile range of 0-1.

These strategies cover multiple aspects such as leveraging emerging technologies, data analysis, overcoming resistance to reform, and managing stakeholder expectations, and are critical to the sustainability of continued growth of high-tech companies.

From Table 4 it was found that:

Focus on Digital Transformation: CTOs are anticipated to lead digital transformation initiatives, with a median score of 5 and an interquartile range (IQR) of 0.5. This indicates a strong consensus that this aspect will be a core responsibility of future CTOs.

Data-driven Decision-making: CTOs will leverage data analysis and artificial intelligence for informed decision-making, with a median score of 5 and an IQR of 1, indicating broad agreement on its significance.

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Table 4 Prediction of CTO's Future Role. (Section 4)

Item	Mdn	Mo	IQR	Seq
Focus on digital transformation	5	5	0.5	1
Data-driven decision-making	5	5	1	1
Leading position in cybersecurity	5	5	1	1
Sustainability and Ethical Technology Adoption	5	5	1	1
Customer-centric innovation	5	5	1	1
Agility and flexibility	5	5	1	1
Collaboration with senior executives	5	5	0.5	1
Talent management and skill enhancement skills	5	5	0.5	1
Emphasize the innovation ecosystem	5	5	0.5	1
Addressing Regulatory Challenges	5	5	0.5	1

Leading Position in Cybersecurity: CTOs are expected to prioritize cybersecurity, scoring a median of 5 with an IQR of 1, highlighting its critical importance in future CTO roles.

Sustainability and Ethical Technology Adoption: CTOs will actively promote sustainable and ethical technology practices, scoring a median of 5 with an IQR of 1, suggesting consensus on its significance.

Customer-centric Innovation: Future CTOs will focus on customer-centric innovation, scoring a median of 5 with an IQR of 1, indicating broad agreement on its importance.

Agility and Flexibility: CTOs will embrace agility and flexibility, scoring a median of 5 with an IQR of 1, reflecting consensus on its role in future CTO responsibilities.

Collaboration with Senior Executives: Collaboration with senior executives will be crucial, scoring a median of 5 with an IQR of 0.5, indicating broad agreement on its importance.

Talent Management and Skill Enhancement: CTOs will play a key role in talent management and skill enhancement, scoring a median of 5 with an IQR of 0.5, suggesting consensus on its significance.

Emphasize the Innovation Ecosystem: Future CTOs will prioritize building innovation ecosystems, scoring a median of 5 with an IQR of 0.5, indicating broad agreement on its importance.

Addressing Regulatory Challenges: The CTO will address regulatory challenges, scoring a median of 5 with an IQR of 0.5, suggesting consensus on its significance.

Discussion

The findings of this study are as follows:

1 CTOs in high-tech enterprises should possess Technical leadership and strategic thinking; Collaboration and team building; Adaptability and Resilience; and Innovation and R&D.

2 Sustainable development strategies that high-tech enterprises need to possess are Environmental Sustainability Initiative; Social Responsibility and Ethical Practice; and Economic sustainability and long-term viability.

3. CTO Strategies for Improving the Sustainable Growth of High-tech Enterprises include Key Steps to Making the Most of Emerging Technologies; Key Steps to Getting the Most out of data analysis and decision-making; Strategies for overcoming corporate resistance to sustainable reforms; and Strategies for managing stakeholder expectations.

4 Prediction of the CTO's Future Role is Focus on digital transformation; Data-driven decision-making; Leading position in cybersecurity; Sustainability and ethical technology adoption; Customer-

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centric innovation; Agility and flexibility; Collaboration with senior executives; Talent management and skill enhancement skills; Emphasize innovation ecosystem; and Addressing Regulatory Challenges. This is consistent with Chen & Cheng (2019) that traits of leaders, impression management ability, transcendence, and leadership abilities, special expertise can increase impression. Leadership outcome has a strong positive correlation with transformational leadership and a negative correlation with passive-to-avoid leadership (Antonopoulou et al, 2021).

The CTO leadership model is important in driving the growth of high-tech industries by fostering innovation and strategic technological advancements within enterprises. This research emphasizes the role of CTOs as key players in aligning technology strategies with business goals, ensuring that companies not only stay ahead of technological trends but also effectively leverage these advancements for competitive advantage. CTOs act as both leaders and strategists in the deployment of new technologies and processes that are essential for industrial growth and efficiency. Their influence goes beyond simply adopting technology to defining their organizations' future technological trajectory, hence promoting sector-wide innovation and development in high-tech industries. (Minshall et al., 2010).

Leadership in high-tech enterprises is pivotal for fostering sustainable growth, as these leaders are required to not only keep pace with rapid technological advancements but also ensure that their organizations adapt sustainably. Effective leadership in high-tech sectors involves a blend of visionary and transformational leadership styles (Bu, & Guo, 2019). This combination helps in steering the organizations towards innovation while maintaining a commitment to sustainability. Leaders who emphasize ethical practices and encourage a culture of continuous learning and adaptation significantly contribute to long-term organizational resilience and success (Gupta & Singh, 2020; Chen & An, 2009). These insights suggest that for high-tech enterprises aiming at sustainable growth, selecting, and developing leaders with these capabilities becomes crucial.

The findings highlight the multifaceted nature of the Chief Technology Officer (CTO) role in high-tech enterprises, emphasizing the diverse skill set required for success. Adaptability emerges as a key theme, underlining the importance of navigating uncertainty and leading through change. Collaboration and team building are essential for fostering an innovative work environment, where diverse perspectives are valued. Technical expertise remains foundational, but it is the integration of technical prowess with strategic acumen and interpersonal skills that distinguishes exceptional CTOs. The evolving nature of the CTO role necessitates continuous learning, adaptation, and ethical leadership.

Sustainable development strategies are imperative for high-tech enterprises, encompassing environmental, social, and economic dimensions. Initiatives such as energy efficiency and responsible innovation contribute to reducing ecological footprints and addressing social responsibilities. Financial planning and risk management are essential for economic sustainability. Recognizing the interconnectedness of these strategies is crucial, as environmental sustainability positively impacts social responsibility and economic resilience. Collaboration with stakeholders, strategic partnerships, and talent management are vital for sustainable growth in the dynamic high-tech industry.

CTOs play a critical role in driving high-tech enterprises toward sustainable growth by integrating emerging technologies with strategic goals. An innovative mindset and collaboration beyond organizational boundaries are essential for success. Talent acquisition and development are crucial for navigating the complexities of emerging technologies. Addressing concerns around data privacy and cybersecurity is paramount for risk and security management.

The future role of CTOs will be shaped by digital transformation, data-driven decision-making, and ethical technology adoption. They must possess a strong strategic vision, leadership skills, and an ethical compass to address complex challenges. Customer-centric innovation, agility, and collaboration with senior executives are vital for aligning technology with broader organizational goals. Open, collaborative approaches to innovation, talent development, and technology leadership will be key in shaping the future landscape of high-tech enterprises.

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Recommendation

Several recommendations can be proposed to enhance Leadership for the sustainable growth of high-tech enterprises in Guangxi Province

Invest in Continuous Learning: Encourage CTOs to prioritize continuous learning and professional development to stay abreast of emerging technologies and industry trends.

Foster Collaboration: Promote a culture of collaboration and open communication within the organization, enabling CTOs to work effectively with cross-functional teams and senior executives.

Embrace Innovation: Create an environment that fosters innovation and experimentation, empowering CTOs to drive technological advancements and create value for the organization.

Prioritize Regulatory Compliance: Provide support and resources to ensure that CTOs can effectively address regulatory challenges and uphold data privacy and security standards.

Develop Leadership Skills: Offer leadership development programs to enhance CTOs' adaptive leadership, conflict resolution, and talent management abilities.

Encourage Diversity and Inclusion: Recognize the importance of diversity and inclusion in driving innovation and promoting a more equitable work environment.

By implementing these recommendations, high-tech enterprises can empower their CTOs to navigate complex challenges, drive sustainable growth, and position the organization for long-term success in the competitive technology landscape.

Integrated Sustainability Policies: Develop integrated sustainability policies that align environmental, social, and economic objectives. Ensure these policies are embedded in organizational culture and decision-making processes.

Technological Innovation for Sustainability: Foster a culture of innovation that prioritizes sustainable practices in technological development. Encourage the use of technology to address environmental challenges and contribute positively to society.

Employee Engagement: Implement comprehensive employee engagement programs focusing on sustainability awareness and active participation in green initiatives. Employees should be champions for sustainability within the organization.

Continuous Monitoring and Evaluation: Establish robust monitoring and evaluation mechanisms to assess the impact of sustainable development strategies. Utilize data-driven insights to refine and enhance these strategies over time.

Strategic Partnerships: Explore strategic partnerships and collaborations with organizations that share similar sustainability goals. Leverage partnerships to access complementary technologies and expand market reach.

Talent Management: Prioritize talent management and retention strategies to attract and retain skilled professionals. A proactive and diverse workforce is integral to driving innovation and ensuring long-term viability.

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