

IBM Institute for Business Value
C-suite Series: The 2021 CTO Study

The CTO Revelation

Redefining responsibility, accelerating discovery



In Q2 and Q3 2021, the IBM Institute for Business Value (IBV) surveyed 5,000 C-suite technology leaders, including both Chief Technology Officers (CTOs) and Chief Information Officers (CIOs). A select group of executives was contacted for in-depth qualitative interviews, revealing insights about their on-the-ground experience leading organizations throughout a period of exceptional disruption.

With respondents spanning 29 industries and 45 locations worldwide, this study marks our first significant look at the evolving influence and responsibilities of the CTO role. For more details, see “Research and analysis methodology” on page 40.

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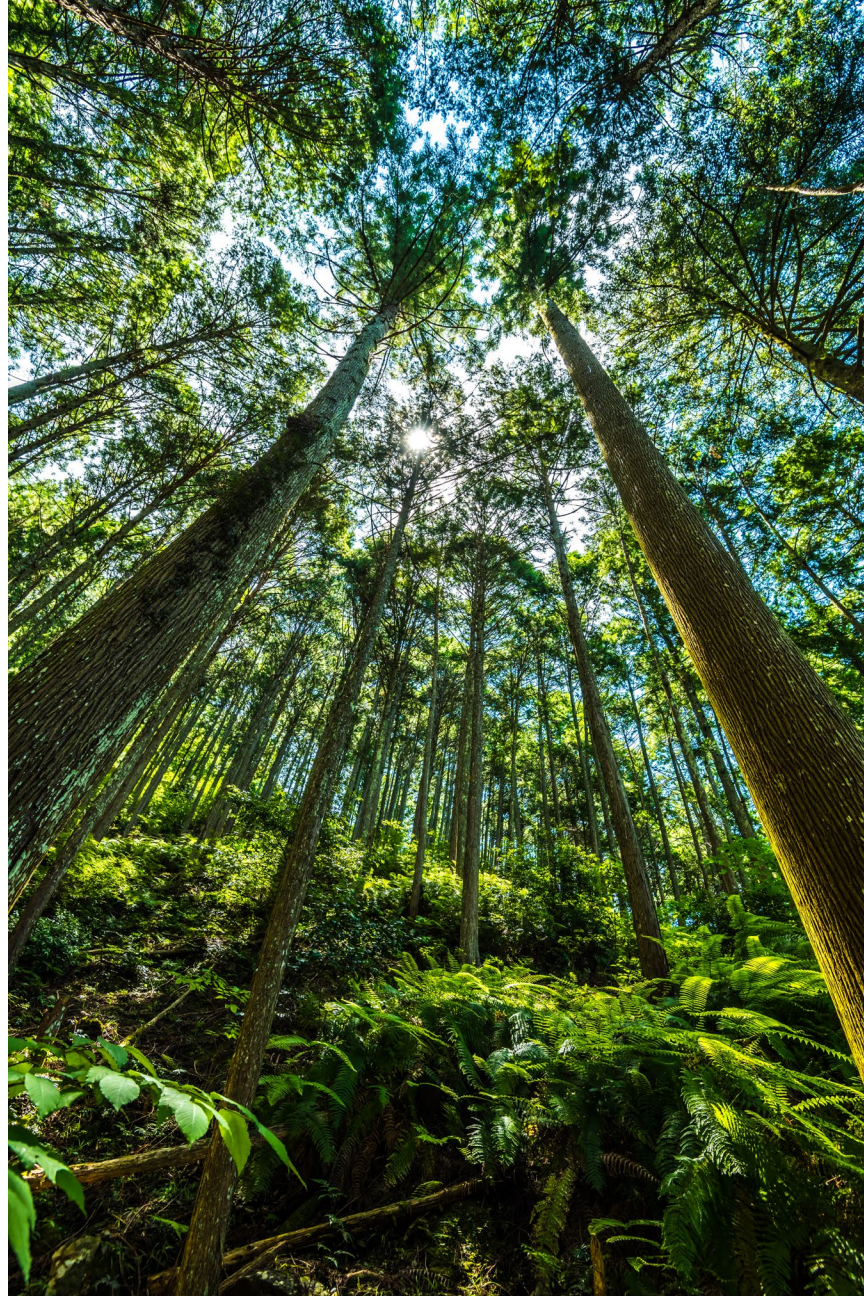
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Introduction

*Bringing tech strategy
to the forefront*

*“When everything becomes digital,
technology becomes the core business
and the CTO becomes as key as the CEO.”*

Moises Nascimento, CTO, Banco Itaú

More and more, today’s technology leaders are discovering their own heightened importance within the C-suite. Already at the center of modern society, technology’s influence has been further elevated by pandemic-accelerated innovations. Organization leaders rely on experts in tech strategy, architecture, and operations now more than ever, giving Chief Technology Officers (CTOs) amplified authority and responsibility that will only grow in the years ahead.

That the CTO has become one of the most strategic roles within an organization may come as a revelation for some, yet this positioning has been years in the making. CTOs are aligned to lead a new “Virtual Enterprise” model that is emerging, fueled by a fresh post-digital approach to business opportunity.¹

This model is based on the speed and scale of cloud technologies—notably the flexibility and interoperability of hybrid cloud, the rapid results generated by combining artificial intelligence (AI) and automation, and the location-independence afforded by cloud-enabled platforms and services. Together, these technologies create synergies and unlock new value streams that are orders of magnitude greater than what could be enabled individually.²

As enterprises redefine themselves for survival in a post-pandemic marketplace, the spotlight shifts to technology executives and the organizations they lead. “Technology strategy is intertwined with business strategy,” says Randeep Sekhon, CTO of India-based telecom conglomerate Airtel. Dr. Mark Maybury, CTO of US consumer-goods manufacturer Stanley Black & Decker, observes, “For the first time in our species, technology can empower us with exponential growth enabled by advanced sensors, quantum computing, and artificial intelligence.”

In this inaugural IBM CTO study, we see the tech leadership role increasingly split between the Chief Information Officer (CIO) and the CTO, with the CTO role being relatively new in the C-suite. This is creating a different dynamic around technology and business decisions. “The technologist enables the organization in a digital world,” says Kevin Hanley, Director of Innovation at NatWest Group in the UK. “CTOs are at the center of the business model, impacting decisions downstream and upstream.” Another bank CTO, Moises Nascimento of Brazil’s Banco Itaú, notes, “When everything becomes digital, technology becomes the core business and the CTO becomes as key as the CEO.”

This study explores how CTOs are driving transformation and business value at an astonishing pace. The ascent of the CTO is radically influencing a stronger sense of responsibility around technology decisions, the speed of innovation, and discovery of new solutions. CTOs are also increasingly promoting a philosophy of co-creation and partnerships driven by common values and open standards. In this report, the changing technology culture is discussed in 3 chapters followed by an action guide:

Chapter 1

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CTOs have risen to a position of influence by championing a more strategic—and more accountable—vision of technology

Chapter 2

Collaboration at the crossroads

Tech leaders are advancing business outcomes and working with CIO colleagues to deliver value

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CTO roles can be defined by discrete mandates based on organizational expectations and what defines success for each

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Chapter 1

A rapid ascent— and the responsibility for a better future

As technology has permeated virtually every business function within today's organizations, the role of technology leaders has evolved dramatically in complexity, stature, and impact. They are leading the technology revolution with an eye to the future while simultaneously applying quickly evolving practices to present situations. "CTOs can provoke the right conversations on what the world will look like in 5 years," says NatWest's Kevin Hanley. "We help change the focal length and perspective."

CEOs agree. When we recently asked 3,000 CEOs to identify the C-suite executives most critical to their organizational success, CTOs and CIOs jointly ranked in the top 3 behind CFOs and COOs (see Figure 1). Among CEOs at the top 20% of organizations based on financial performance, technology leaders were second only to CFOs.³

Reporting structures also reflect a radical shift in strategic influence. 40% of CTOs indicated they now report directly to the CEO, and 67% of CTOs said they report directly into the C-suite versus a business unit or geography leader. Almost 30% expect their next role to be a CEO. "Just like CFOs put finance in business terms, CTOs are putting technology in business terms," says Mark Reynolds, CTO of the UK's National Health Service (NHS) Digital. "CTOs now have a voice at the table with CEOs—one of the most important voices."

Managing a tech-fueled future, responsibly

Today's CTOs are charged with transforming technology into a strategic asset and articulating a focused vision for its role—whether through enabling platforms, propelling innovation, or defining responsible and sustainable design patterns and architectural principles. They are well positioned to steer initiatives in a world where the technology function is core to every interaction and every business process.

These technology leaders recognize their role as central to the future success of their organizations. “CTOs are driving innovation and agility, changing the alignment of the C-suite,” says John Hoffman, CTO of the US State of Texas. “CTOs are held accountable.” Juan Gómez-Reino, CTO of Lloyds Bank in the UK, stresses, “The CTO has the role of connecting the dots between business strategy and technology strategy.”

Almost 30% of CTOs surveyed expect their next role to be a CEO.

Figure 1

Tech chiefs climb the ladder of influence

CEOs—and even CTOs and CIOs themselves—recognize the increasing importance of tech leaders to near-term success



Q. (for CTOs/CIOs). Beyond the CEO, which of the following executives will play the most crucial role for your organization over the next 3 years? (n=2,500)

Q. (for CEOs). Who from your C-suite team will play the most crucial role for your organization over the next 2–3 years? (n=3,000)

**The 2021 CEO Study. Find your essential—How to thrive in a post-pandemic reality.” IBM Institute for Business Value. February 2021.

Digital platforms and ecosystems are turning virtually all businesses into technology businesses—whether by reorienting operations around data insights, providing access to adjacent markets, or enhancing integration across the value chain. Emerging technologies—from advanced analytics to hybrid cloud-enabled microservices to AI-driven automation—are fueling both supply and demand. When operations are connected by a common data, integration, and orchestration layer, the combination of these technologies can yield exponential gains in efficiency and financial performance.⁴ (See case study “Yara” on page 7.)

For CTOs, the expanding technology portfolio means extending their vision for technology strategy and architecture in new directions. CTOs are increasingly examining how they design and consume technology services, with a focus on creating a culture of responsibility and sustainability. This encompasses a range of concerns, such as:

- Inspiring innovations that positively impact society
- Promoting secure, transparent, and fair use of data
- Using technologies efficiently
- Addressing bias and fostering equality with inclusive systems
- Reducing environmental and economic impact with conscious code choices
- Designing and operating data centers with an emphasis on energy awareness and environmental impacts.

These imperatives have never been more urgent. For example, by 2030, 21% of projected energy demand is expected to be consumed by information technology.⁵ As more organizations operate in complex cloud environments, CTOs play a critical role in determining where computing occurs and how data is governed.

As noted by CTO Hua Zhu of China’s Hywin Holdings, “The CTO must be a person with in-depth insight into both the industry and corporate governance. What technology can do is to enlarge human efficiency and realize the exponential amplification of growth.”

“CTOs are driving innovation and agility, changing the alignment of the C-suite.”

John Hoffman, CTO of the US State of Texas

Case study

Yara

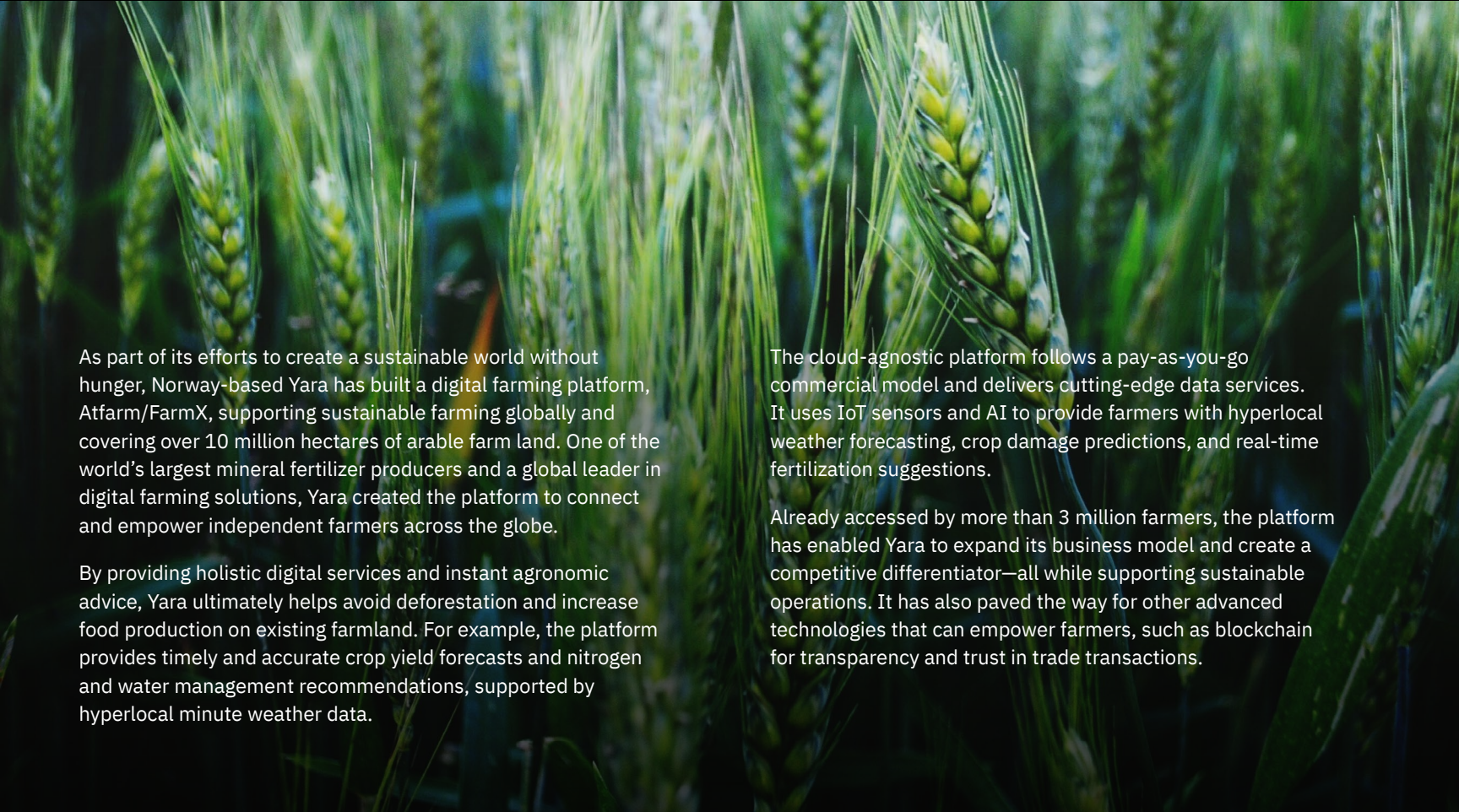
Feeding a growing population

As part of its efforts to create a sustainable world without hunger, Norway-based Yara has built a digital farming platform, Atfarm/FarmX, supporting sustainable farming globally and covering over 10 million hectares of arable farm land. One of the world's largest mineral fertilizer producers and a global leader in digital farming solutions, Yara created the platform to connect and empower independent farmers across the globe.

By providing holistic digital services and instant agronomic advice, Yara ultimately helps avoid deforestation and increase food production on existing farmland. For example, the platform provides timely and accurate crop yield forecasts and nitrogen and water management recommendations, supported by hyperlocal minute weather data.

The cloud-agnostic platform follows a pay-as-you-go commercial model and delivers cutting-edge data services. It uses IoT sensors and AI to provide farmers with hyperlocal weather forecasting, crop damage predictions, and real-time fertilization suggestions.

Already accessed by more than 3 million farmers, the platform has enabled Yara to expand its business model and create a competitive differentiator—all while supporting sustainable operations. It has also paved the way for other advanced technologies that can empower farmers, such as blockchain for transparency and trust in trade transactions.



Investing for impact

During the COVID-19 pandemic, technology leaders have stepped up, helping to address their organizations’ most pressing needs. In fact, according to IBV research, the pandemic prompted 55% of organizations to permanently course-correct their strategies.⁶ This includes accelerating the rate of digital transformation, adjusting the approach to change management, and shifting to more cloud-based business activities.

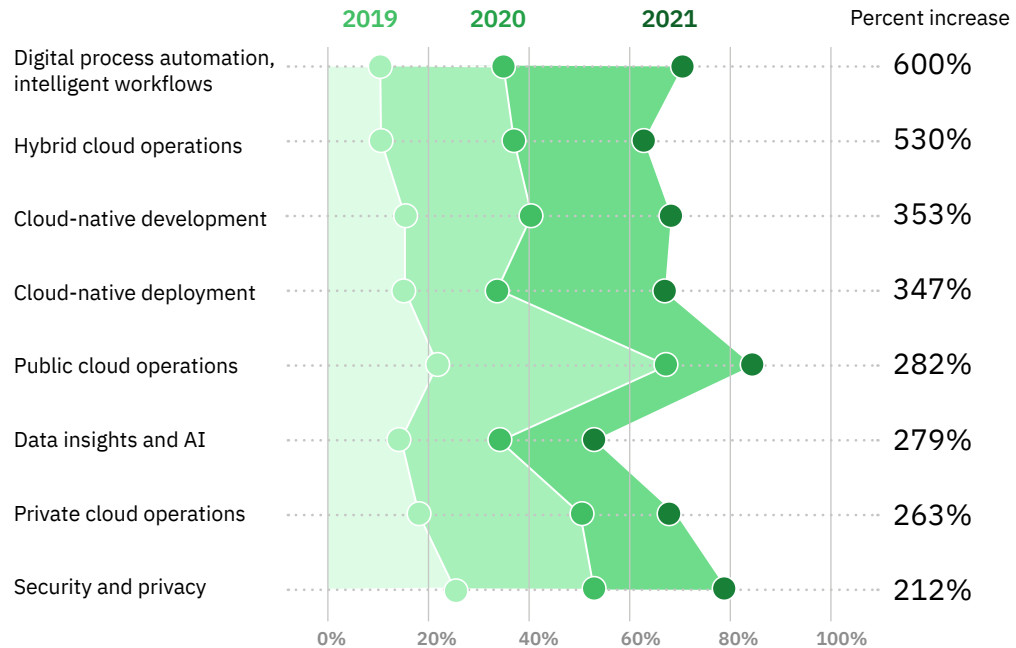
When asked to reflect on the transformation of their organizations, CTOs told us about massive leaps in the maturity of technology platforms and services. Since 2019, more CTOs are reporting increased capability maturity, including 600% more who are experiencing advanced digital process automation capabilities, 530% seeing advanced hybrid cloud operations, 353% realizing advanced cloud-native development, plus surges in those reporting the maturity of other key technologies (see Figure 2).

Figure 2

Technology tidal wave

The pandemic as a whole served as a giant catalyst for tech adoption

Q. Assess your organization's transformation journey in these areas (% reporting advanced capabilities at maturity stages 4 and 5).



CTOs expect continued adoption of emerging technologies to move their businesses forward, both in the short and long term. Not surprisingly, cloud computing is cited by 66% of CTOs among the technologies most likely to help deliver results over the next 2-3 years (see Figure 3). This is followed by IoT (54%) and then advanced analytics (50%).

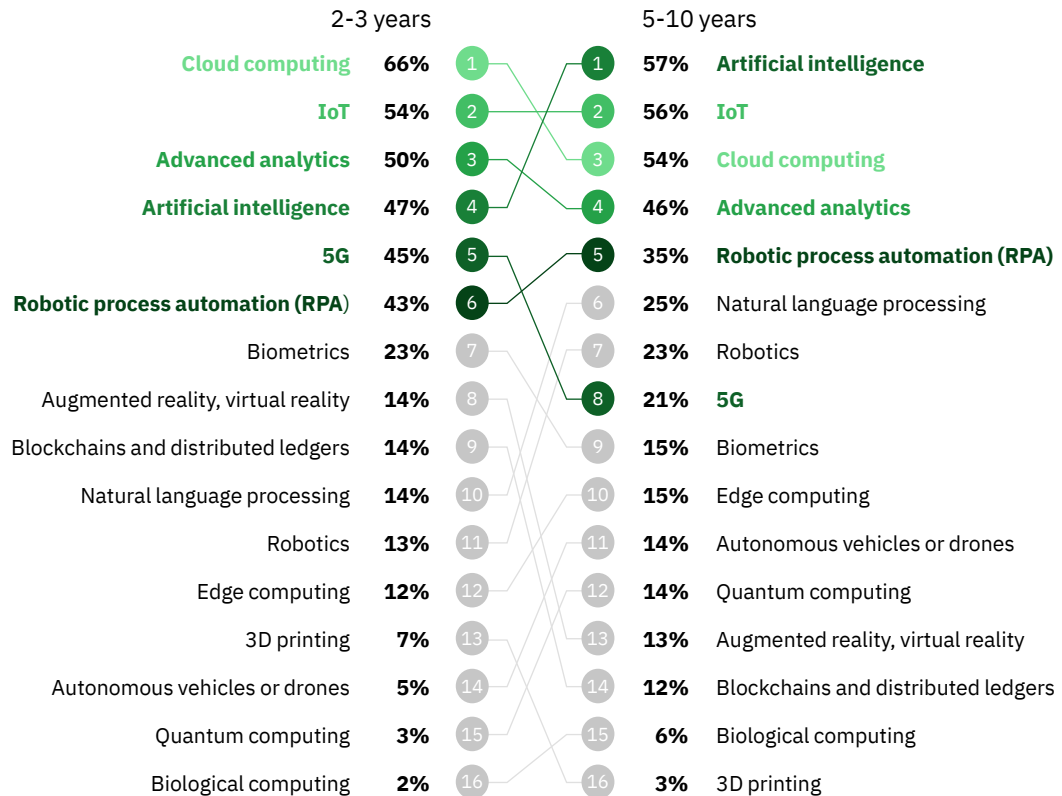
Looking at a longer-term horizon of 5-10 years, 57% of respondents expect AI capabilities to have an impact on their business results (see Figure 3). Both IoT (56%) and cloud computing (54%) remain in the top 3 of most influential technologies.

Figure 3

Building on cloud

CTOs expect cloud and other cloud-enabled technologies to impact their business results

Q. Which of the following emerging technologies will most help deliver the results you need over the following periods: next 2-3 years (short term), next 5-10 years (long term)?



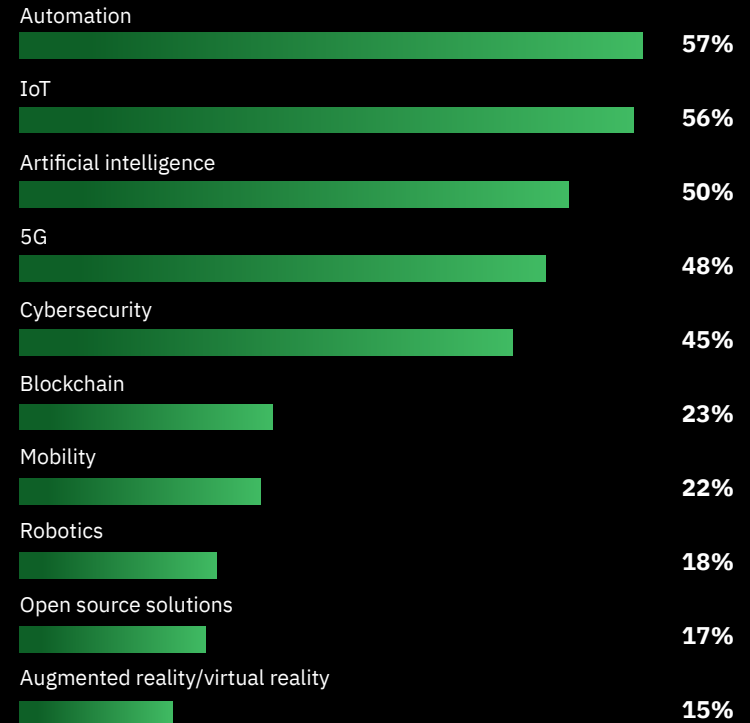
While CTOs project 5G and robotic process automation will be instrumental over the next 2–3 years, they envision these will have less effect on business results over the 5- to 10-year time frame. On the other hand, CTOs expect several technologies to have a growing impact over time. These include natural language processing, edge computing, autonomous vehicles, quantum computing, and biological computing.

Planned financial decisions are aligned with these expectations. Tech leaders stated their plans to invest in emerging technologies, with cloud computing noted as the top expected area. In addition to cloud, CTOs expect to spend the most in automation (57%), followed by IoT (56%) and AI (50%, see Figure 4). This reflects the swift and growing embrace—and effectiveness—of cloud-native platforms, and, in particular, their proficiency at connecting and activating data to enhance engagement and collaboration.

Figure 4

Investing beyond the cloud

Automation, IoT, AI, and 5G rank highest as planned technology investments, in addition to cloud



Q. In which of the following technologies do you expect to invest the most over the next 3 years?

Indeed, emerging technologies can extend data-driven value propositions and cost savings in new ways. For instance, automation holds great promise for reducing the overhead associated with routine business processes. This hasn't gone unnoticed by CTOs. Among those surveyed, 76% say their organizations are effective in terms of automating business processes.

Organizations that integrate core technologies most effectively can experience massive benefits.⁷ Recent IBV research revealed that those strategically integrating cloud with open organizations, operational enablers, exponential technologies, and advanced data capabilities positioned themselves to unlock a 13-fold increase in revenue.⁸ Such gains illustrate the transformative power of a hybrid cloud strategy.⁹

“You [tech leaders] now need to have totally different discussions with the business. And you need to have the confidence to question the business.”

Lotta Karlsson Boman, Vice President and Head of Global Competence Center, Ericsson

The CTO balancing act

The role of CTOs has evolved to encompass some of the organization's most far-reaching capabilities—running the gamut from defining a tech strategy to implementing it responsibly. The strategic nature of their job has placed them in a position of heightened interaction with senior leadership, with 55% of those surveyed noting their primary C-suite engagement is with the CEO and an equal percentage engaging with the Chief Operating Officer (COO) (see Figure 5).

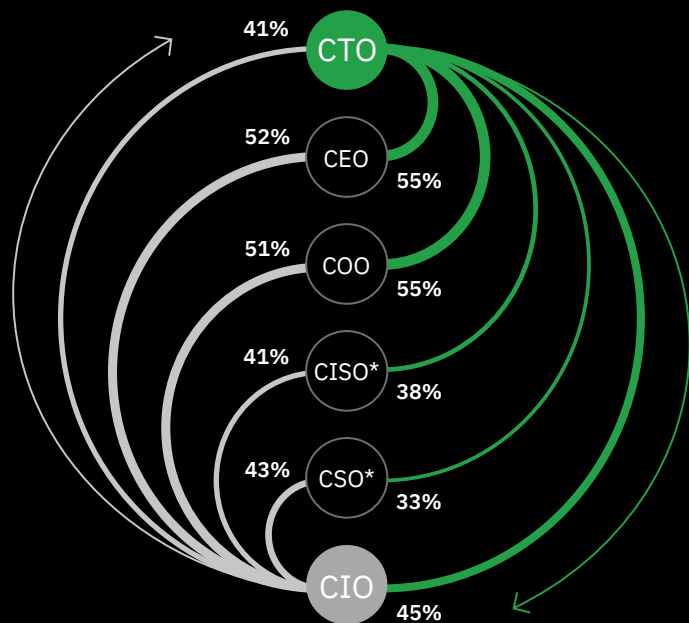
With an increased level of input, tech leaders must refine their communication skills. Ericsson's Vice President and Head of Global Competence Center, Lotta Karlsson Boman, notes, “Many started on a very technical level and then moved into higher management positions. It has been easy to hide behind deep technical discussions. You now need to have totally different discussions with the business. And you need to have the confidence to question the business.”

The breadth of responsibilities also requires a balancing act. On the one hand, CTOs must understand how technology contributes to—and can remediate—operational challenges, while on the other hand, they need to see how technology innovation can seed new opportunities.

Figure 5

The collaborative suite spot

CTOs report engaging with their CEOs and COOs more than other C-suite leaders



“The CTO role is designed to drive innovation, but the CTO should not do technology for technology’s sake,” says Banco Itaú’s Moises Nascimento. “We have to show progress on the business front and connect to the customer experience. Some parts of a road map are the technical foundation and not directly associated with a business outcome. It is key to use the opportunity to educate how the technical foundation contributes to the customer experience.”

Survey respondents echo these ideas, with 85% of CTOs indicating they develop clear value propositions for new tech, and 71% noting that improving customer experiences drives those goals.

With data fueling innovation, it’s no surprise that CTOs add data to their list of central responsibilities. 79% of CTO respondents report a leadership role in their organization’s data strategy—and 70% state that their colleagues look to them for data governance and stewardship. “In order to leverage the power of data,” says CTO David Wood of KPMG in the UK, “I work together with the CIO and the Chief Data Officer to guide the organization towards a more consistent use of platforms and data models.”

However, opportunities are often offset by limitations. When asked what tests them the most, CTO respondents in our survey cited organizational complexity, which outpaced even the burden of legacy systems.

Q. In your organization, which C-suite roles do you interact with most?
*Chief Strategy Officer (CSO). Chief Information Security Officer (CISO)

As CTOs find themselves in a new position of influence and balancing technology tradeoffs, our research shows that both CTOs and CIOs agree on the CTO's core mission: technology strategy, architecture, and operations. More so than before, CTOs are now uniquely positioned to:

- Advise the CEO, C-suite, and the Board on technology strategy and architecture
- Invest in emerging and exponential technologies that allow the organization to fulfill its core mission
- Drive innovation through an accelerated discovery process
- Define principles for the design and implementation of new technologies and their responsible use moving forward
- Forge partnerships that help solve business problems and kindle ideas for new business models.

“The challenges that we’re facing are not within one’s competence but are actually cross-spanning both the CIO and CTO.”

Johan Sporre Lennberg, Vice President of Cloud Service, Ericsson

The CTO-CIO alliance: Delivering value, together

The good news for CTOs tackling these tasks: they are not alone. As the CTO role has ascended to the senior-most ranks of the organization, CTOs are turning to their CIO counterparts as crucial allies within the technology function.

“The challenges that we’re facing are not within one’s competence but are actually cross-spanning both the CIO and CTO,” observes Johan Sporre Lennberg, Vice President of Cloud Service at Ericsson. “Who will be affected and to what extent? And who will take the lead to drive the solutions?”

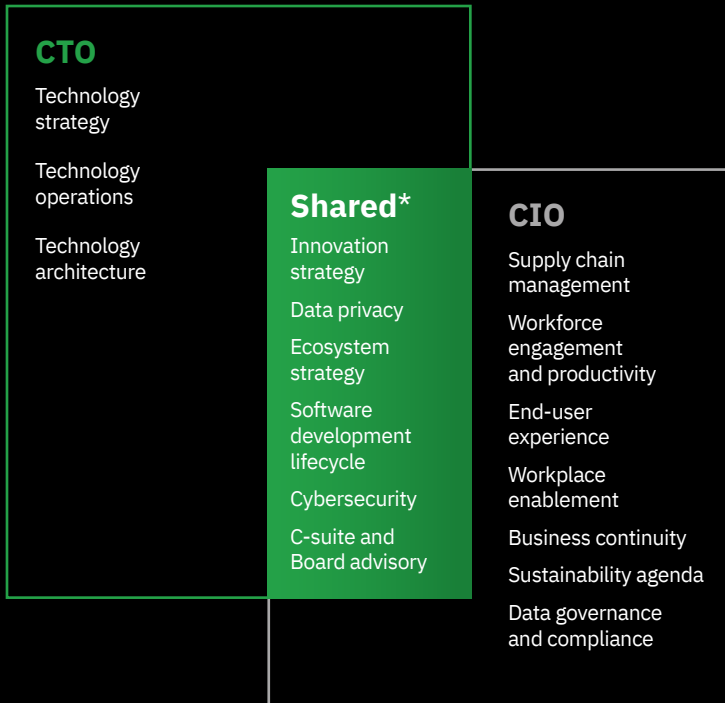
At a high level, the technology function has a common set of responsibilities that are typically distributed between CTOs and CIOs (see Figure 6). Regardless of industry or organization, CTOs are focused on a core set of responsibilities, namely technology strategy, operations, and architecture; in contrast, CIO responsibilities vary greatly by industry and organization.

CIOs tend to own a broad set of responsibilities that bridge from the C-suite to the business units. More than 70% of surveyed technology leaders report that CIOs own back-office applications, including supply chain, workforce engagement, end-user experience, and workplace enablement.

Figure 6

Finding common ground

How responsibilities are allocated across the technology function



“I play a complementary role with the CIO,” says Sarah Greasley, Chief Technology Officer of UK insurance firm Direct Line Group. “I would characterize us as bridging the technology and business as we move to a much more agile organization.”

One might generally characterize CIOs as operating *across* the organization, often in a “diagonal” sense of interfacing at different levels of the organization. Their success depends on their proficiency in doing so. On the other hand, CTOs are inclined to focus on a more defined set of responsibilities, which enables them to address the most strategic opportunities and the most pressing challenges influencing their organization’s use of technology.

“I play a complementary role with the CIO. I would characterize us as bridging the technology and business as we move to a much more agile organization.”

Sarah Greasley, CTO, Direct Line Group

Q. In your organization, who owns each of the following responsibilities?

*Degree to which responsibilities are shared can vary by industry and organization.

Our research found that allocation of CTO duties can vary based on industry, organizational structure, and reporting relationships. We delve into those differences further in Chapter 3 by way of exploring 3 distinct CTO mandates. Next, however, let's explore how CTOs and CIOs work both together and independently across technology responsibilities to align to business objectives and deliver value for their organizations. As we show in Chapter 2, effective collaboration can be critical to boosting an organization's performance.

Chapter 1.

3 essential questions for CTOs

How can you capitalize on your influence as CTO to accelerate business growth?

What new technology-driven initiatives can you implement to cut through organizational complexity?

How could you build greater interest in and support for the actions defined in your technology road map?

Chapter 2

Collaboration at the crossroads

Tech adoption in and of itself doesn't deliver optimal value.¹⁰ But when deployed strategically, effectively, and often in tandem, technologies such as hybrid cloud, AI, and automation can enable modern enterprises to transform massive change into substantial benefits. How to best lead the technology function and drive success? The executives we spoke with consistently returned to a specific theme: collaboration. For example:

"CTOs need to be working hand in glove with CIOs," says CTO Abhijit Shah of Nippon Life India Asset Management Ltd. "Integration capability is the key; the ones who can fuse their core systems, data with their partners' systems seamlessly, can get the business value at a much faster pace."

"CTO and CIO partnerships are key to success, an egoless matrixed delivery of the technology function," notes a senior vice president of a Canadian banking firm.

Curiously, despite what appears to be widely recognized as the ideal situation, our research reveals that CTOs and CIOs are often working independently. Only 45% of CTOs indicate frequent interaction with their CIO counterparts. Similarly, just 41% of CIOs highlight frequent interaction with their CTO peers.

So, why aren't CTOs and CIOs sitting together at lunch? "Culturally, it can be a bit of a battle," says the Canadian bank's senior vice president. As KPMG CTO David Wood puts it, "The CIO is more focused on technology infrastructure and operations, whereas I am more focused on setting technology strategy. We are both grateful for each other, although I'm not sure I'd want to do his role!"

Ultimately, however, it is collaboration that fuels the most impactful business results, as we will quantify below. "There is a constant tradeoff between the CTO and the CIO," says Cristina Alvarez, Global Chief Technology Officer of Spain's Banco Santander. "But if we disagree on strategy, transformation is not going to happen."

"There is a constant tradeoff between the CTO and the CIO. But if we disagree on strategy, transformation is not going to happen."

Cristina Alvarez, Global CTO, Banco Santander

Boosting business value through technology maturity, effectiveness, and ROI

The measure of high performance is when technology investments consistently enhance operational capabilities and drive business outcomes. “For successful innovation, we need to establish common objectives and key results (OKRs) across business and technology,” notes Direct Line’s Sarah Greasley. “The alignment needs to be very strong.”

To dive deeper into the ways technology leaders are delivering business value, we assessed the organizations in our study on 3 technology measures:

Technology maturity—The stage of their cloud, AI, automation, and security journeys

Technology effectiveness—Their agility, data management, governance, and resilience

Technology ROI—The return from their technology investments, normalized by industry.

Our analysis indicates that organizations reporting higher technology maturity, technology effectiveness, and technology ROI achieved better business performance. In particular, we discovered financial gains accelerated during the pandemic—organizations with higher technology measures built a substantial advantage over their peers (see Figure 7).

Figure 7

High performers pull away

Organizations with stronger tech measures report a financial performance premium relative to peers with lower tech measures

Tech maturity

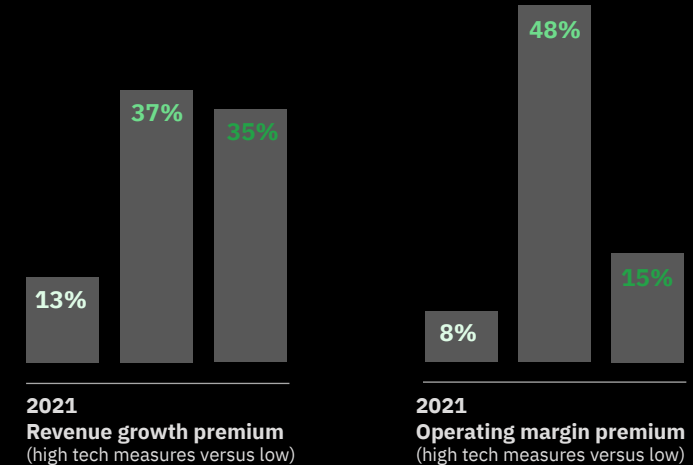
Assessed by the stage of their cloud, AI, automation, and security journeys

Tech effectiveness

Assessed by their agility, data management, governance, and resilience

Tech ROI

Assessed by the return on their technology investments, normalized by industry



We also found that organizations enjoyed additional financial gains based on the strength of collaboration between CTOs and CIOs. Our analysis revealed:

- Organizations with high technology measures combined with high CTO-CIO collaboration showed substantial operating margin improvements versus those with high technology measures alone (see Figure 8).

In terms of revenue growth, we discovered the effects of CTO-CIO collaboration are more muted:

- Of organizations with high CTO-CIO collaboration, those with high technology maturity saw 6% revenue gains while those with high technology effectiveness saw 2% gains.

Finally, our analysis suggests that technology and collaboration reinforce each other in ways that magnify the impact of each:

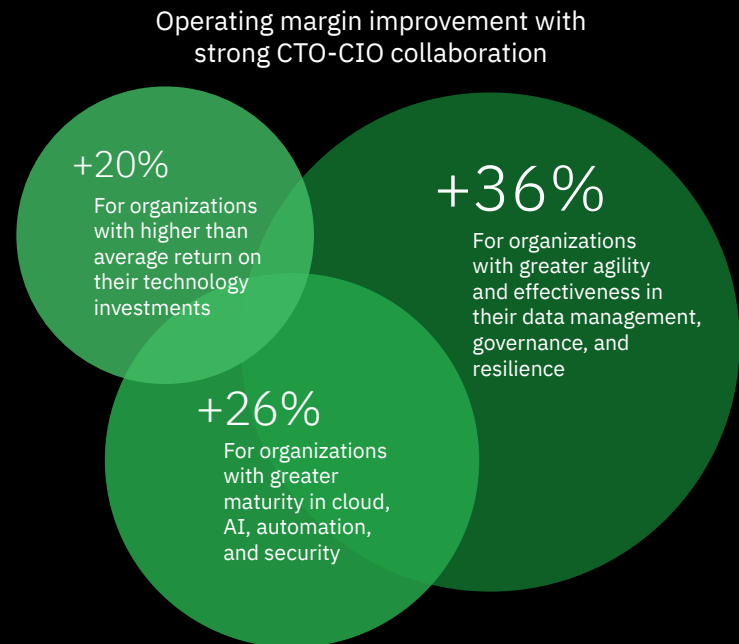
- Organizations with strong CTO-CIO collaboration and high technology measure scores reported operating margin improvements averaging 39% over organizations with low levels of collaboration and low technology measure scores.

Thus, the combination of advanced technology measures plus strong CTO-CIO collaboration had a net compounding effect on financial performance, as measured by revenue growth and operating margin.

Figure 8

Collaboration counts

Organizations see dramatic operating margin improvement from strong CTO-CIO collaboration



Synergy for success: A tapestry of 6 value drivers

Success is based on an organization's ability to drive business value and capabilities throughout the enterprise. As business and technology operations converge, technology leaders need to think differently to align their business, operations, and technology strategies.¹¹

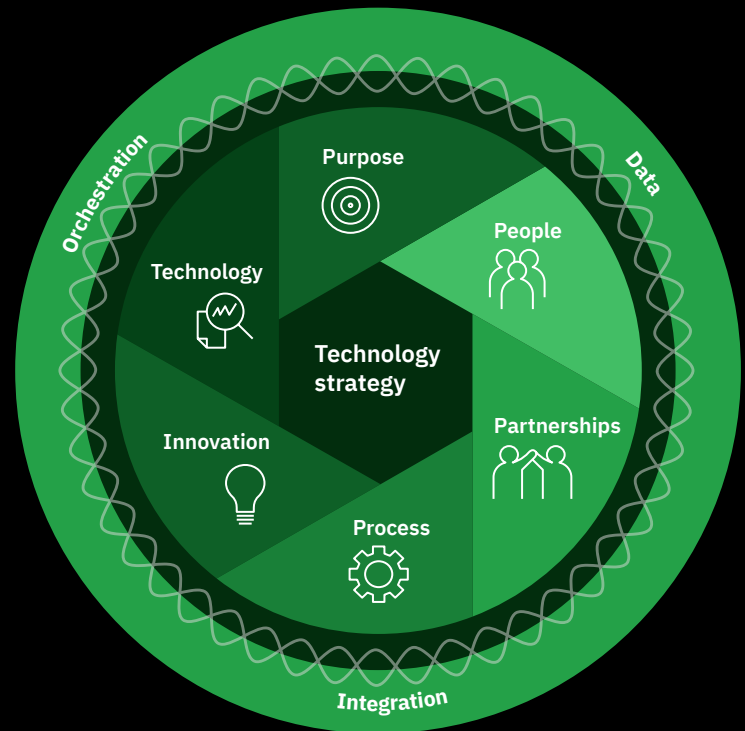
To best conceptualize this approach, consider how value is created across the enterprise. It requires a combination of 6 value drivers working together: purpose, people, partnerships, process, innovation, and technology (see Figure 9).

What is so special about these value drivers? Taken individually, they can only do so much. But in combination, they can create new value propositions that dramatically extend the reach and impact of technology.¹²

Figure 9

Core
convergence

Integration and collaboration
enhance the power of
6 value drivers



Our analysis suggests such value stems from the ability to bring assets, resources, insights, and opportunities together—dynamically and in response to real-time variables. The efficiency and effectiveness of these capabilities can make a huge difference in business outcomes. These capabilities are less centralized and more distributed. Realizing the associated benefits depends less on optimizing resources, and more on enhancing connections and accelerating insights.

Given the growing complexity and interdependence of technology strategy and operations, these responsibilities are increasingly shared among technology leaders. For CTOs, this often means taking a leadership role in developing a comprehensive, holistic approach to technology strategy, architecture, and operations. For CIOs, it may mean leveraging technology as a core business capability and serving the day-to-day technology needs of diverse constituents and stakeholders.

With this context, we explore in depth the 3 value drivers CTOs tend to use to lead strategic efforts: innovation, purpose, and partnerships.

Value driver 1: Innovation

CTOs are at the heart of evolving innovation efforts within the Virtual Enterprise. More than 80% of CTOs surveyed indicate that accelerating the discovery process is central to future growth for their organizations.

“Innovation is a competitive battleground,” says NatWest’s Kevin Hanley. “We need to drive the culture inside the organization, shine the light on technology direction and big broad trends, and think about what it all means to the business.”

But how can organizations pick up the pace of innovation?

One answer lies in the scientific community’s response when faced with the urgency of the COVID-19 crisis. Technologies such as AI and hybrid cloud empowered scientists to speed up the scientific method and remove long-standing bottlenecks.¹³ With the pandemic as a proving ground, employing modern technologies forms the basis for a new era of accelerated discovery. This approach can extend advances beyond the realm of science, leading not only to new business opportunities but entirely new asset classes, services, and markets. The difference: those willing to adopt the rigor of the scientific method of discovery and experimentation to make evidence-based business decisions. (See case study “IBM and the Cleveland Clinic” on page 23.)

Developments in the materials science field demonstrate the potential of scaling the scientific method to accelerate discovery.¹⁴ Deep search, AI- and quantum-enriched simulation, generative models, and cloud-based, AI-driven laboratory environments are delivering faster innovation in a domain known for intensive, highly complex workloads. Hybrid cloud has provided a bridge across a mix of data and compute resources—facilitating the integration of additional technologies, such as quantum computing and intelligent simulation—that enable scientific discovery at speed and scale.

CTOs recognize this race to innovate and the influence they can have. “CTOs are the chief innovators, both of technology as well as business models,” explains Stanley Black & Decker’s Dr. Mark Maybury. “Enabled by data, sensors, IoT, quantum computing, and AI, we can see things we couldn’t before, model and anticipate trends. All of a sudden, we can transform discovery. We can invent augmented by machine intelligence. But we need to have everybody involved. It’s as much a sociological challenge as a technology challenge.”

As primary owners of technology strategy, CTOs control the levers that accelerate discovery and innovation. In terms of collecting data and insights, 85% of CTOs say they rely on an experimental approach across the value chain. What’s more, 75% of CTOs say that experimentation and discovery happen through ecosystem partners, with 74% citing the use of dedicated innovation teams.

“CTOs are the chief innovators ... we can transform discovery. We can invent ... But we need to have everybody involved.”

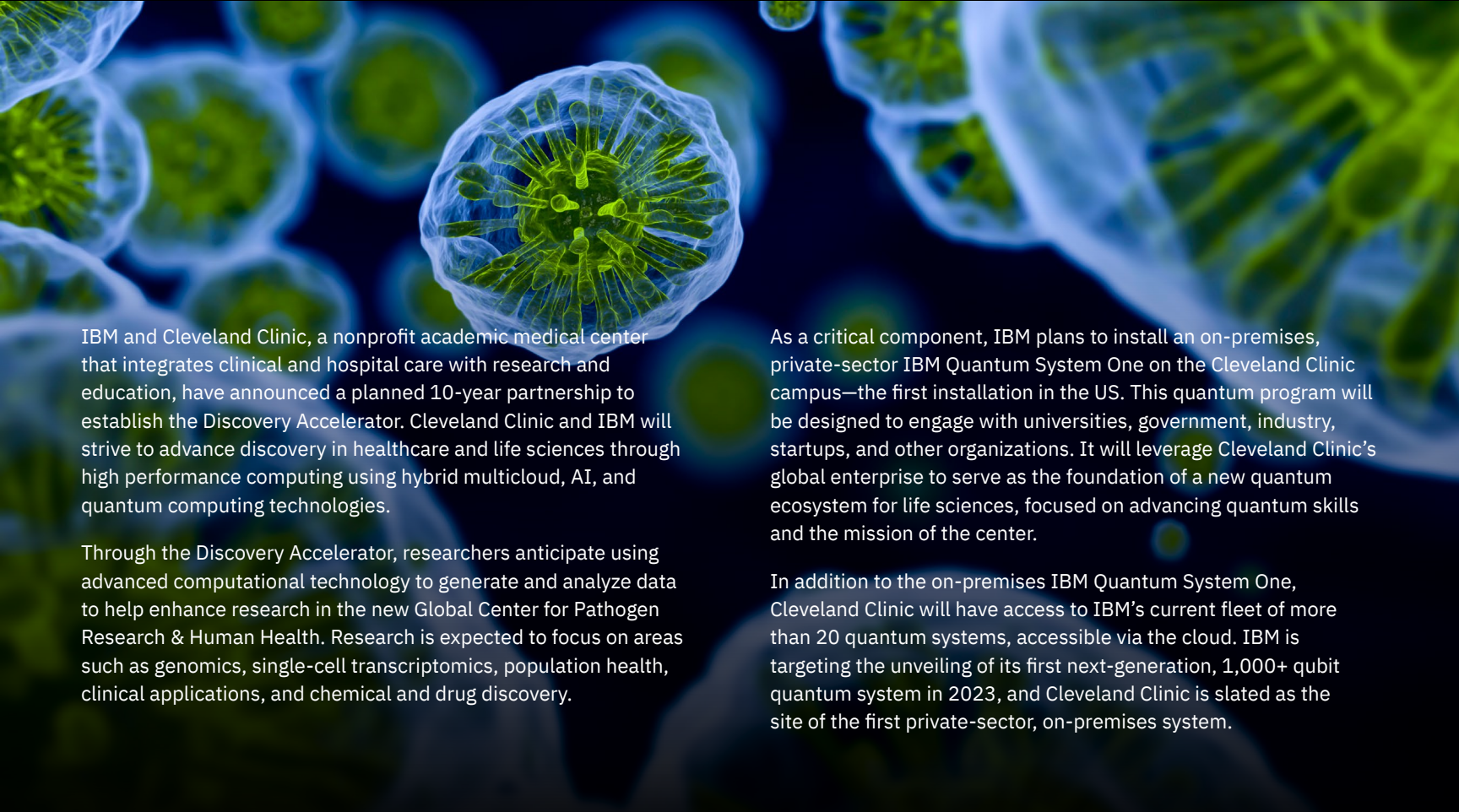
Dr. Mark Maybury, CTO, Stanley Black & Decker

Flexibility to choose and change technologies is also key. “Keeping us agile is more important than sticking to a technology road map,” notes Airtel’s Randeep Shekhon. “The inability to adapt can be very detrimental. Whoever innovates faster, whoever takes the risk, will win.” Shekhon points to his company’s Airtel IQ innovation as a result: “If we had not created an open platform, Airtel IQ would not be possible. The network is becoming more flexible and malleable, and technology choices allow us to build in different ways.”

Case study

IBM and Cleveland Clinic

Using the power of quantum to tackle key healthcare challenges¹⁵



IBM and Cleveland Clinic, a nonprofit academic medical center that integrates clinical and hospital care with research and education, have announced a planned 10-year partnership to establish the Discovery Accelerator. Cleveland Clinic and IBM will strive to advance discovery in healthcare and life sciences through high performance computing using hybrid multicloud, AI, and quantum computing technologies.

Through the Discovery Accelerator, researchers anticipate using advanced computational technology to generate and analyze data to help enhance research in the new Global Center for Pathogen Research & Human Health. Research is expected to focus on areas such as genomics, single-cell transcriptomics, population health, clinical applications, and chemical and drug discovery.

As a critical component, IBM plans to install an on-premises, private-sector IBM Quantum System One on the Cleveland Clinic campus—the first installation in the US. This quantum program will be designed to engage with universities, government, industry, startups, and other organizations. It will leverage Cleveland Clinic's global enterprise to serve as the foundation of a new quantum ecosystem for life sciences, focused on advancing quantum skills and the mission of the center.

In addition to the on-premises IBM Quantum System One, Cleveland Clinic will have access to IBM's current fleet of more than 20 quantum systems, accessible via the cloud. IBM is targeting the unveiling of its first next-generation, 1,000+ qubit quantum system in 2023, and Cleveland Clinic is slated as the site of the first private-sector, on-premises system.

Value driver 2: Purpose

In our conversations with executives, they voiced a recurring theme: the unique sense of ownership from CTOs around connecting the values and purpose of an organization with broader considerations. They also discussed technology's influence and its impact on the environment and society at large (see "Perspective: Focus on sustainability" on page 25).

"We can save lives with technology," notes NHS Digital's Mark Reynolds. "CTOs bring the right tools to bear at the right places. The national booking service for COVID-19 vaccines didn't exist. Now we make a million bookings a day. With the data we had available, we were able to identify patients at risk of death from COVID-19 with 30,000 conditions and so provide guidance and support."

"CTOs can make the business case for change around technology. How can we reduce environmental impact? How can we reduce the impact of process automation on jobs? How can we reskill our talent to become future ready?"

Fezile Dali, CTO, Standard Bank

Adds Direct Line's Sarah Greasley, "We have a purpose for good with technology. COVID-19 raised awareness of what tech can do. It's much more explicit now. How can we use technology to prevent things from happening rather than react?"

In a time when responsible computing is at the forefront, CTOs are wrestling with important, yet hard-to-answer, questions such as:

- Are they minimizing the impact of infrastructure on the environment?
- Are they being thoughtful in having efficient code?
- Do they use citizen data in ethical ways?
- Are their systems inclusive?
- Do they cater to the diversity of humanity that they serve?¹⁶

CTO Fezile Dali of South Africa's Standard Bank adds to this list of considerations. "CTOs can make the business case for change around technology. How can we reduce environmental impact? How can we reduce the impact of process automation on jobs? How can we reskill our talent to become future ready?"

As Dali indicates, tech leaders are looking both inward and outward with their responsibilities. Ethics, along with diversity and inclusion, are rated as the most important attributes for engaging employees, according to CTOs. The same is true when selecting technology partners; CTOs state their highest priority is identifying those whose values align with theirs. This leads us to our third value driver: partnerships.

Perspective

Focus on sustainability

Sustainability is a rapidly growing C-suite priority, with new ecosystem-based business models helping to resolve some of the biggest challenges of our time.¹⁷ In fact, in recent IBV research, 9 in 10 companies said they'll be working on various sustainability initiatives across the enterprise by the end of 2021, and 7 in 10 executives expect their sustainability development goals to improve operational effectiveness, agility, and drive.¹⁸

Sustainability issues are increasingly important to consumers as well. Compared to 2 years ago, 22% more consumers say environmental responsibility is very or extremely important when deciding on a brand. A full 84% of consumers now indicate environmental sustainability is at least moderately important.¹⁹

CTOs and CIOs are recognizing the potential for technology to support sustainability, citing it as the top area for technology impact over the next 2-3 years in this study. New digital business models can help fulfill both a sense of purpose and environment, social, and governance (ESG) goals.

Sustainability objectives are important when selecting cloud partners as well. CTOs are positioned to advocate for new cloud services that are responsible. "We need to invest to become sustainable," says Juan Gómez-Reino of Lloyds Bank. "It's not just the cost of making change, but it's about our technology choices and how we select cloud providers."

Recognizing the power of partnerships to address global challenges, IBM has collaborated with Whitespace to launch the Responsible Computing Tech Innovation Challenge. This initiative is designed to identify ways small companies can work together to develop innovative clean technologies.²⁰

Value driver 3: Partnerships

Ecosystems and partnerships are essential to unlocking the potential of a Virtual Enterprise. To create value propositions that transcend traditional boundaries, organizations require sophisticated and robust data sharing practices; policies that support changing compliance requirements; intelligent workflows that extend beyond functional siloes; a common approach to cybersecurity threats; and open innovation procedures that facilitate cross-functional collaboration.²¹ These responsibilities are calls-to-action for technology leaders.

CTOs have front-row seats to digital transformation and can play an instrumental role in enabling extended workflows based on emerging “threads of value.”²² Prominent among their responsibilities, CTOs are tasked with translating the promise of modern technologies to the C-suite and, increasingly, to the Board. Additionally, CTOs are finding new opportunities in strategic partnerships. By sharing insights, services, and customers across the ecosystem, partnerships can unlock entirely new business models. (See case study “The Hartree National Centre for Digital Innovation” on page 28.)

“We are going from an era of ‘how’ to an era of ‘who,’” explains NatWest’s Kevin Hanley. “Ecosystem partnerships are naturally set up to do that. Winners are those that create an environment to bring partnerships together. The differentiator is the ability to leverage that ecosystem.”

In reflecting on the goals of partnerships, CTOs in this study stated that sharing data insights effectively was the top objective. Among the other highly cited purposes: enhancing transparency and visibility, improving trust, and advancing collaboration.

As we noted above, partnerships also play a key role for CTOs in furthering innovation and discovery—3 out of 4 CTOs cite ecosystem partners as a significant conduit. They also stress the importance of choosing partners with both values and purpose that align with the organization.

“CTOs are the glue to bring partner ecosystem players together,” says Airtel’s Randeep Shekhon. “Not all solutions now are coming from big players. Ten years ago, 90-95% of industry challenges were solved by big players. Now we are seeing smaller players with niche solutions. CTOs can be the catalyst to bring entrepreneurs and small companies to scale.”

The details of building partnerships are key. “Partnering outside the CTO organization opens great opportunities to build the right relationships, work with diverse teams to get support, and create the right culture. This in turn helps ensure we are continuously driving for digital innovation that matters to our clients and business,” observes Allan Porter, Senior Vice President and Chief Technology Officer of Canada’s Sun Life Financial.

Shigeki Takayama, Representative Director and Vice-Presidential Executive Officer of chemicals company Asahi Kasei Corporation in Japan, notes, “Partnerships are only effective if they bring in the elements we need. Just like what is done in the M&A process, tech chiefs need to seek out potential partners—without necessarily ruling out partnering with competitors.”

Takayama continues, “We need to discover what themes the market is pursuing, identify technologies to bring these themes to reality, and partner with companies that specialize in these technologies.”

Both human and technological factors determine the success of partnerships in unlocking exponential value—a concept CTOs recognize. “There are logical places to plug into the ecosystem,” notes Mark Thomas, Chief Architect of US insurer Progressive. “We need to uncover points of integration where innovation is likely. Some partners work at a different speed. Just figuring out how to mesh the gears and make mutually beneficial relationships versus transactional relationships can be a learning experience.”

“There are multiple customer journeys that run across our and partners’ systems,” says Nippon Life India’s Abhijit Shah. “And we have to solve for multiple things. What customer data is shareable? Do we have the same levels of embedded security? How do we meet our obligations for regulatory compliance and privacy laws?”

“We need to discover what themes the market is pursuing, identify technologies to bring these themes to reality, and partner with companies that specialize in these technologies.”

Shigeki Takayama, Representative Director
and Vice-Presidential Executive Officer, Asahi Kasei Corporation

Case study

The Hartree National Centre for Digital Innovation

Accelerating discovery through community

The United Kingdom Research and Innovation's Science and Technology Facilities Council (STFC) is building a community dedicated to discovery. The Hartree National Centre for Digital Innovation (HNCDI) in Daresbury has a mission to support UK businesses and the public sector by reducing the risk of experimentation and exploration in the adoption of innovative new digital technologies.

The program, a partnership with the Hartree Centre and IBM, will apply AI, high performance computing and data analytics, quantum computing, and cloud technologies to accelerate discovery and develop innovative solutions to industry challenges, such as materials development, life sciences, manufacturing, and environmental sustainability. In the process, HNCDI will help businesses enhance productivity, create new skilled jobs, and boost regional and national economic growth.

HNCDI will help organizations navigate 4 key stages of digital adoption by providing accessible training and application-focused skills, equipping staff to take full advantage of digital technologies, exploring and discovering the technologies businesses need to succeed, turning ideas into practical digital solutions for industry, and identifying and preparing for emerging technologies needed to futureproof the UK economy.

In addition to IBM quantum and hybrid cloud resources, scientists in the program will have access to a vast portfolio of IBM commercial and emerging AI technologies focused on materials design, scaling and automation, asset management, supply chain, and trusted AI.

Insights on the other 3 value drivers: Technology, people, process

In this chapter, we've focused on the transformation agents most relevant to CTOs. It is important to recognize, however, that CTOs are actively leveraging *all 6* value drivers. For CTOs interested in a deeper dive, we elaborate further on the 3 additional value drivers—technology, people, and process—in our companion CIO Study.²³

“Partnering outside the CTO organization opens great opportunities to build the right relationships, work with diverse teams to get support, and create the right culture.”

Allan Porter, Senior Vice President
and Chief Technology Officer, Sun Life Financial

Chapter 2.

3 essential questions for CTOs

What actions are you taking to accelerate innovation and co-creation with ecosystem partners?

How are you championing ethics, social responsibility, and sustainability through design principles?

Which technologies are you using to expedite the path from experimentation to delivery of new solutions aligned to business outcomes?

Chapter 3

Finding focus— The 3 CTO mandates

As the technology portfolio expands and diversifies, so too do the responsibilities of technology leaders. How the CTO or CIO role is defined often reflects factors that have little to do with the individual leader and more to do with organizational structure and allocation of responsibilities.

To gain insight into how and where CTOs may gain the greatest value from working with their CIO counterparts, it is important to understand how the CTO role has been defined in specific organizations.

CTO roles are, in general, remarkably homogeneous in their responsibilities. Of those surveyed for this report, more than 90% cite technology strategy, technology operations, and technology architecture among their key areas of ownership, and these areas are where they primarily spend their time. Interestingly, CIOs were rarely so consistent in their responses. CTOs also predominantly identify themselves as technology visionaries and transformational business leaders. Their main measure of success is the launch of technology-enabled platforms.

But while the CTO role has less variation when compared to the CIO role, CTOs serve in a variety of capacities. These are based on how the technology leadership function has been defined by their organizations, the scale and maturity of the technology function, and the visibility and influence of the technology function at the C-suite level.

To help CTOs better contextualize their experiences as compared to that of their peers, our research identified 3 distinct CTO mandates: Technology Stewards, Operational Experts, and Hybrid Heroes (see Figure 10). In identifying the CTOs who address these mandates, we focused on clusters of responsibilities and associated success criteria, rather than individual characteristics or leadership styles.

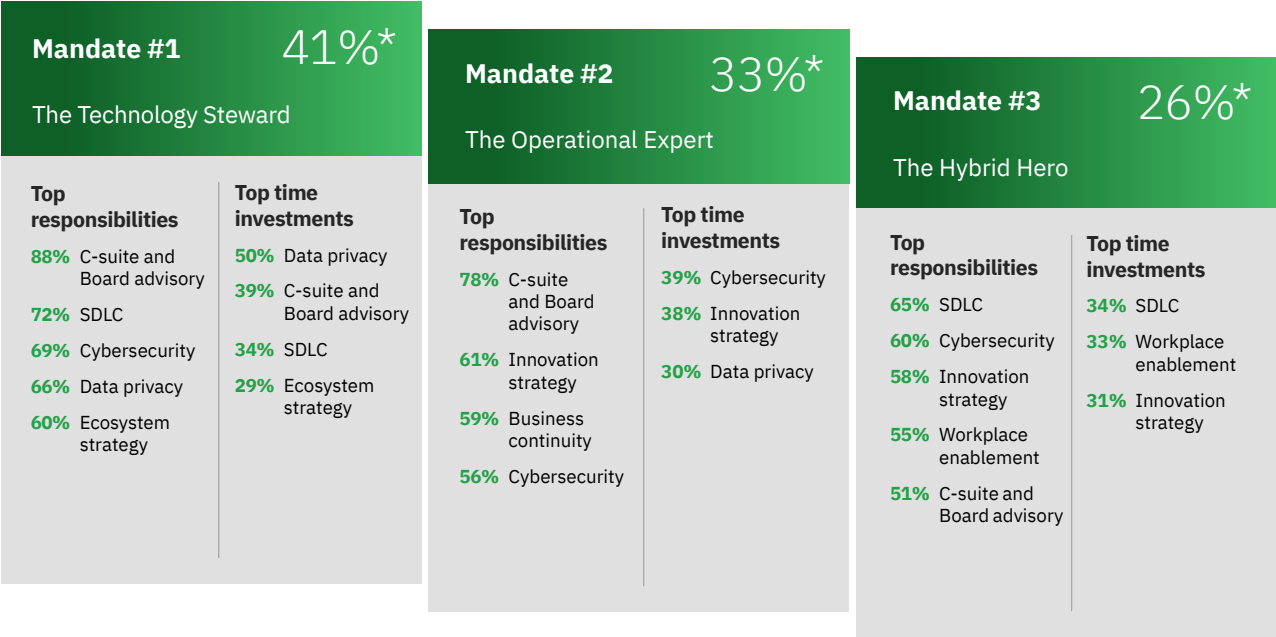
While to some extent, every organization delineates the role to fit its own unique needs, these mandates reflect typical ways in which organizations define the CTO’s role today. Within these common sets of responsibilities, a given CTO may approach the role differently based on personal strengths, leadership style, and understanding of the organization.

Figure 10
The 3 CTO mandates

Top responsibilities and time investment for all mandates:

- Technology strategy
- Technology operations
- Technology architecture

**Percentages of CTOs in our respondent sample, based on IBV data analysis.*



Reflecting the evolution of the CTO role, organizations are adapting what they're looking for from technology leaders. CTO and CIO titles have become more fluid as the role of the technology function grows, with some organizations choosing to combine the roles. Indeed, in our sample, one group of CTOs describes their position as including what might be considered a combination of both CTO and CIO responsibilities. This echoes similar findings from our companion CIO Study.²⁴

By focusing on how their responsibilities fit into their organization's larger technology strategy, CTOs can collaborate and coordinate more effectively with other business and technology leaders. In working together, technology leaders can optimize the distribution of responsibilities to avoid overlap and close gaps. As we've shown, the value of strong CTO-CIO collaboration can significantly improve organizational performance.

90% of responding CTOs cite technology strategy, technology operations, and technology architecture among their key areas of ownership.

CTO Mandate #1. The Technology Steward

These CTOs represent about 40% of our global survey sample and are distinguished by the outward-focused nature of this directive. When it comes to identifying and building strategy, this group is encouraged to identify and incorporate insights and inspiration from outside the organization. In addition, these CTOs most commonly describe themselves as organizational and ecosystem integrators.

Technology Stewards consider advising the C-suite and Board as their top responsibility, cited by 88% of respondents. The second-highest rated area: orchestrating the software development life cycle (SDLC), noted by 72%.

These focus areas are reflected in how they spend their time as well, with advising the C-suite and Board (39%) and SDLC (34%) among their top choices. Data privacy (50%) actually topped the list with ecosystem strategy (29%) also ranking in the top 4.

However, Technology Stewards are not lone wolves or disconnected from their organizations. In fact, they report a high rate of collaboration within the technology function. While looking outward, they also prioritize applying any new insights internally. This group reports the highest technology effectiveness as well. While the technology maturity of these CTOs' organizations is only middle-of-the-road, their progress is fueled by new perspectives.

CTO Mandate #2. The Operational Expert

These CTOs, representing about a third of our global survey sample, are distinguished by the internally focused nature of their mandate. They are tasked with building a forward-looking strategy from the inside out, influenced and informed by business unit needs. When identifying tech priorities, this group uses what's available and working, and looks for ways new technology can enhance the value of their existing investments.

Like the Technology Stewards, the Operational Experts identify advising the C-suite and the Board as their top responsibility, cited at a lower, but still substantial, 78% rate. Their additional areas of responsibility reflect the operational nature of their jobs: innovation strategy (at 61%), business continuity (59%), and cybersecurity (56%).

When it comes to how this group of CTOs spends their time, it is somewhat striking that C-suite and Board advice does not land in the top grouping. Instead, Operational Experts cite cybersecurity and innovation strategy as their top time investments—priorities that protect and grow their core operations.

Interestingly, this group reports the *lowest* collaboration with CIOs among the 3 CTO mandates. And, as would be expected given their inward focus, their organizations also have the lowest technology maturity among the 3 mandates. However, that focus seems to pay off in terms of ROI, as Operational Experts report the highest technology ROI on investments.

CTO Mandate #3. The Hybrid Hero

This group of CTOs represents just over a quarter of our survey respondents. They might well be described as “CIOs in disguise” as they seem to straddle both CTO and CIO responsibilities.

The key signal for this mandate: advising the C-suite and Board is cited by only half of respondents as a top responsibility, putting that specific priority in *fifth* place for these CTOs. Notably, the top 4 priorities include a broad range of areas, from the SDLC (cited by 65% of respondents), to cybersecurity (60%), innovation strategy (58%), and workplace enablement (55%).

The time demands on Hybrid Heroes are more fractured and dispersed—similar to CIOs. Their role is focused more on driving business revenue, suggesting the utility-focused nature of this group’s mandate.

Perhaps unsurprisingly, this group reports the lowest technology effectiveness among the 3 cohorts. But these Hybrid Heroes deliver dramatically when it comes to collaboration and tech maturity. With a broader mandate covering more areas of ownership and partnership opportunities, these CTOs report high collaboration and the highest tech maturity.

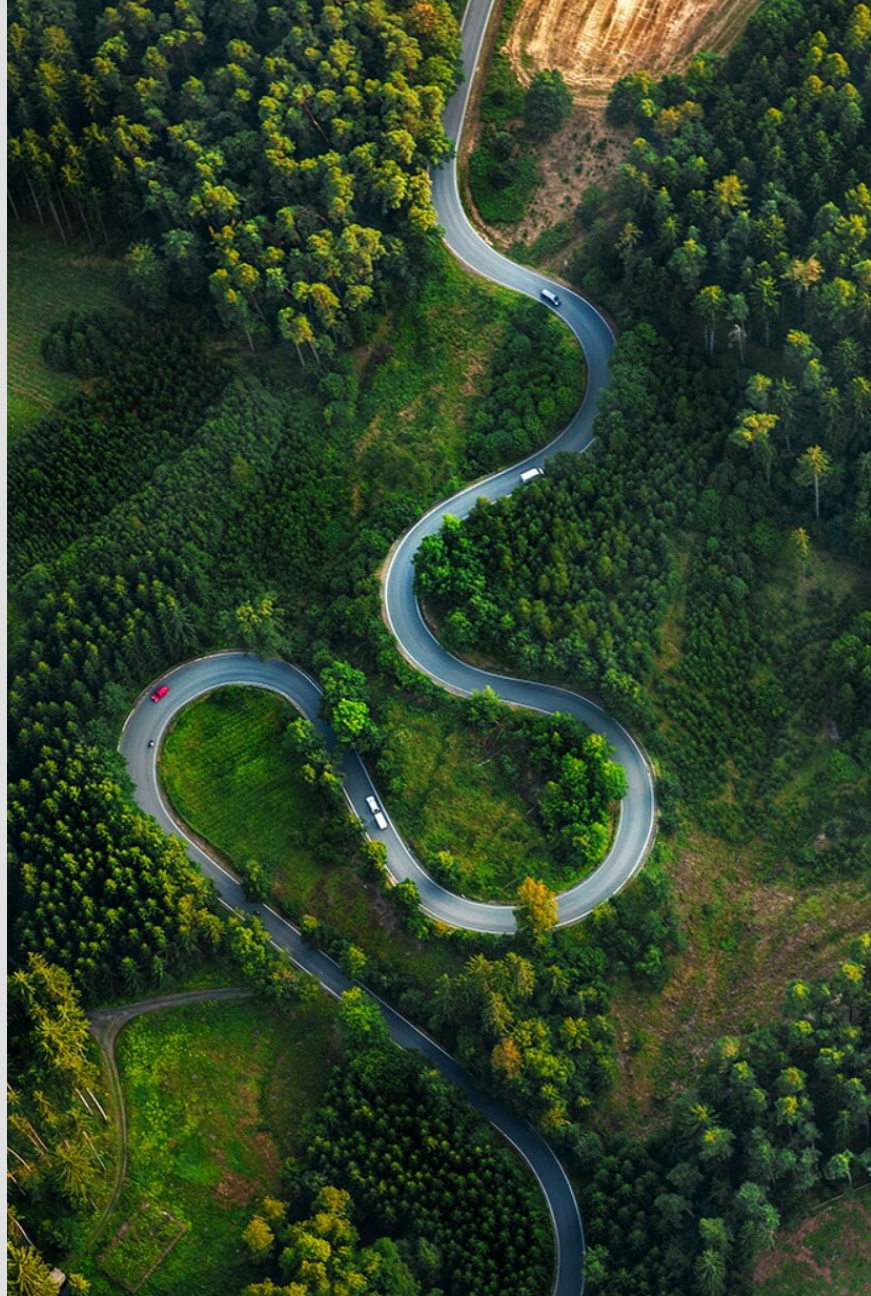
Chapter 3.

3 essential questions for CTOs

How are you actively building a team of collaborators to complement the strengths of your specific mandate?

Where can you best apply your personal leadership style to enhance your influence and impact on organizational success?

What steps are you taking to fully ingrain a technology agenda into your organization's vision for business growth?



Action guide

Planning for the road ahead

The CTO's world is profoundly different than it was a couple of years ago. Organizations where CTOs embrace the challenges and changes as strategic opportunities can build on strong technology leadership and aim for a decisive advantage moving forward. Successful CTOs understand the businesses they support, the evolving technology and risk landscape, and how to connect the pieces.

“There is no separation between business and technology anymore,” says Fábio Napoli, CTO at Brazil's Banco Itaú. “CTOs decide the best choices directly with the business.”

The stakes are high, but so are the prospects for success. Technology investments are driving greater collaboration, increased effectiveness, and modern ways of working beyond organizational boundaries. The time is now to seize this new reality with energy and openness.

*“There is no separation between
business and technology anymore.
CTOs decide the best choices directly
with the business.”*

Fábio Napoli, CTO, Banco Itaú

Recommended actions for all CTOs

Model responsible leadership

- *Think beyond the IT function.* Define your technology agenda to advance a greater sense of purpose for your entire organization and ecosystem.
- *Commit to conscientious computing.* Implement and advocate for accountable practices around infrastructure, such as minimizing environmental footprints and fostering the ethical use of data.
- *Cultivate an inclusive culture.* Promote diversity and inclusion in developing and advancing technology systems and the consumers they serve.

Envision and invest in a bold future

- *Anticipate opportunities.* Use a “telescopic lens” to develop and implement a technology road map that differentiates your business in the short and long term.
- *Recognize technology’s potential.* Flexibly adapt emerging technologies and the new business models they facilitate.
- *Hack the scientific method.* Challenge traditional innovation and discovery processes and unlock faster paths to better business outcomes.

Pursue new possibilities with unexpected partners

- *Pick partners with principles.* Seek organizations with compatible values and priorities and who make informed choices.
- *Grow competencies.* Define a business ecosystem that complements your current capabilities and challenges you to grow.
- *Unleash creativity.* Nurture a culture of co-creation that extends beyond your organization.

Mandate-specific recommendations

Actions for the Technology Steward CTOs

- *Double down on strategy by transcending boundaries.* Use your C-suite influence to build a community of technology and business leaders working collaboratively toward a common mission.
- *Share your story.* Recognize your successes in melding business objectives and the technology estate and inspire other leaders inside and outside the organization.
- *Take purposeful action.* Exploit the potential of technological capabilities to promote inclusion, accountability, and other cultural and community factors.

Actions for the Hybrid Hero CTOs

- *Turn challenge into opportunity.* Promote a compelling strategic vision to move beyond short-term crisis management and specialized operations towards integrated technology and business outcomes.
- *Deploy the hybrid work environment.* Use emerging technologies to re-orient and better orchestrate the IT services supporting engagement, collaboration, productivity, and business value.
- *Bring time horizons into focus.* Define objectives in distinct time horizons of 1 year, 3 years, and 5 years to prevent short-term decisions from impeding long-term goals.

Actions for the Operational Expert CTOs

- *Think deeply, selectively.* Prioritize your success criteria by aligning them to the areas where tech teams deliver the greatest value.
- *Don't lose the forest for the trees.* Don't let your focus on core business operations blind you to broader strategic priorities. Improve business performance using underlying technologies such as hybrid cloud, advanced analytics, integration, and automation.
- *Unlock new value streams.* Foster a high-performance atmosphere where infrastructure, capabilities, and skilled resources combine to create advantage.

Research and analysis methodology

In Q2 and Q3 2021, the IBM Institute for Business Value (IBV), in cooperation with Oxford Economics, interviewed 2,500 Chief Information Officers (CIOs) and 2,500 Chief Technology Officers (CTOs) from 45 locations and 29 industries. These interviews were conducted virtually.

The IBV supplemented data collection with in-depth conversations with more than 20 CTOs globally. These quantitative and qualitative interviews focused on the evolving role of the CTO, the emergence of the CTO as a technology leader, the shift to operating models centered on collaboration and partnership, as well as CTO leading practices and success factors. Interviews were conducted from May to September 2021.

We designed data collection by country, industry, and organizational size. To better understand pre-pandemic and post-pandemic impacts, we captured operational and financial data for the period 2018-2021. In terms of data analysis, we sought to understand the impacts of collaboration on the technology leadership function as a whole, inclusive of both CIOs and CTOs. The strength of CTO-CIO collaboration was based on the frequency of interaction and the extent to which they view their counterparts as critical to organizational success over the next 3 years.

To dive deeper into the ways technology leaders are delivering business value, we also assessed respondents on 3 technology measures:

Technology maturity—The stage of their cloud, AI, automation, and security journeys

Technology effectiveness—Their agility, data management, governance, and resilience

Technology ROI—The return from their technology investments, normalized by industry.

The IBV converted these measures into standardized scores to facilitate comparison across categories and understand the extent to which factors influenced each other. In addition, we conducted a regression analysis to determine how the 6 value drivers—purpose, people, partnerships, process, innovation, technology—influence the 3 technology measures. This was supplemented by a financial analysis of enterprise-wide revenue growth and operating margin. The analysis was structured around various performance scenarios and models were adjusted to enhance goodness of fit.

We also used a segmentation logic to define 3 core CTO identities, which we characterized as distinct CTO leadership mandates, based on responses to specific items from the survey instrument.

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New Orchard Road
Armonk, NY 10504

Produced in the United States of America
December 2021

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