Research Insights

IBM **Institute for Business Value**

The Virtual Enterprise

The Spark of Science and Data-led Innovation

IBM

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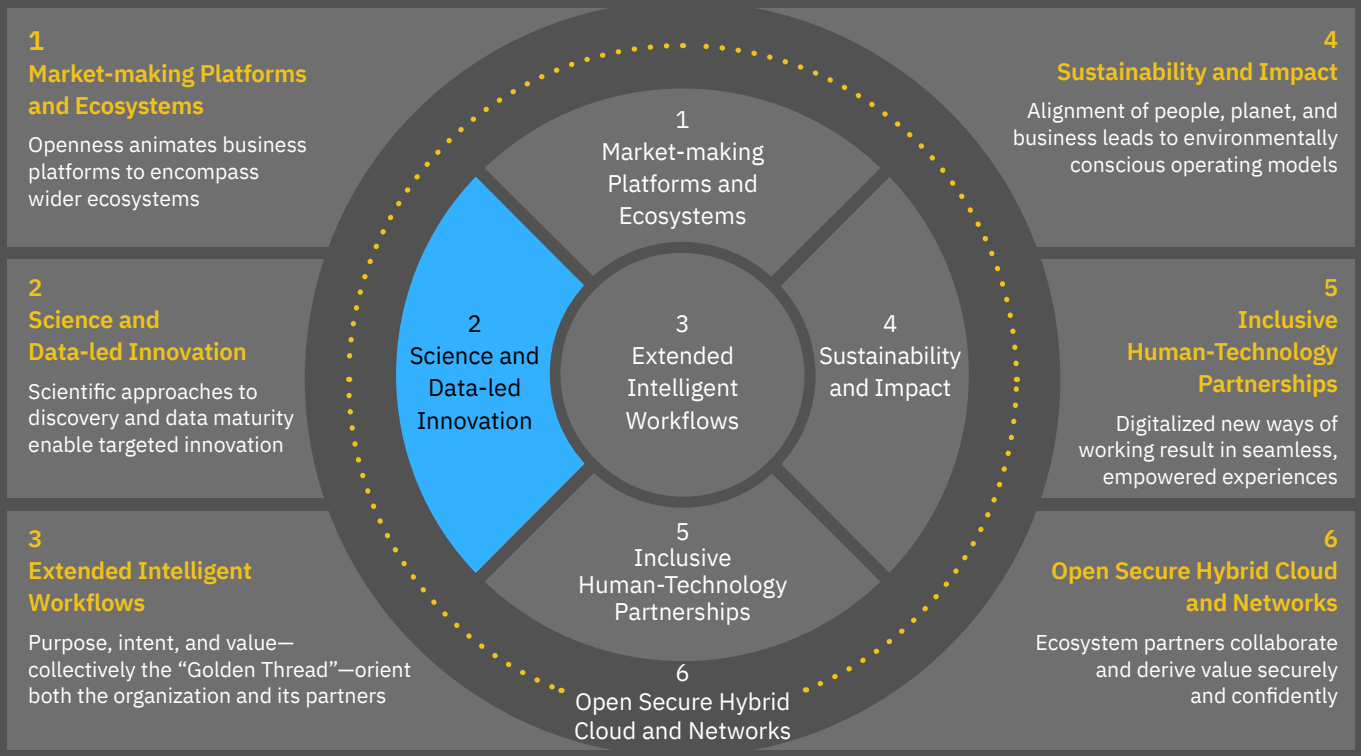
Technology is transforming the business models of enterprises across the globe, creating new opportunities for growth and fresh benchmarks of cost and efficiency. The ability to apply AI, automation, blockchain, the Internet of Things (IoT), 5G, cloud, and quantum computing at scale has made the promise of Cognitive Enterprises real.

As we place this revolution in the context of an increasingly virtual world, we see even more power arising from the ecosystems, digital workflows, and networked organizations that are made possible. The Virtual Enterprise is emerging, supported by a “Golden Thread” of value that animates the enterprise and binds ecosystem participants (see Figure 1).

The openness of the Virtual Enterprise accelerates access to new sources of product and service innovation. It takes a scientific discovery approach, constantly experimenting, relying on predictive and prospective analysis fueled by the massive amounts of data it can access from itself and its ecosystem partners. More and more industries are seeing the value that used to be the preserve of R&D-led industries (for example, pharmaceuticals) as they look forward rather than backward and mine the information in their value chains to spark creativity.

Figure 1

Building blocks of
the Virtual Enterprise



The Virtual Enterprise makes ecosystems the heart of its strategy to enhance innovation, make markets, and massively enhance capabilities.

How science and data-led innovation can unlock new solutions

The Virtual Enterprise is fundamentally one that looks forward and outward. It does not seek to innovate or drive decisions based on history and internal information, but through the combination of predictive and prospective analysis based on massive access to data and new kinds of crowd and swarm intelligence.

The Virtual Enterprise is also more rigorous, pursuing a deeper scientific discovery approach to innovation. And with COVID vaccines developed and tested in months instead of years, scientific discovery is the concept du jour. What if we could apply a similar accelerant to business innovation?

Experimentation, simulation, and testing of hypotheses have long formed the core of scientific discovery. For the Virtual Enterprise, access to exponential technologies such as AI, IoT, and quantum computing enables analogous processes for business—faster than ever before—and across many different industries (see Figure 2).

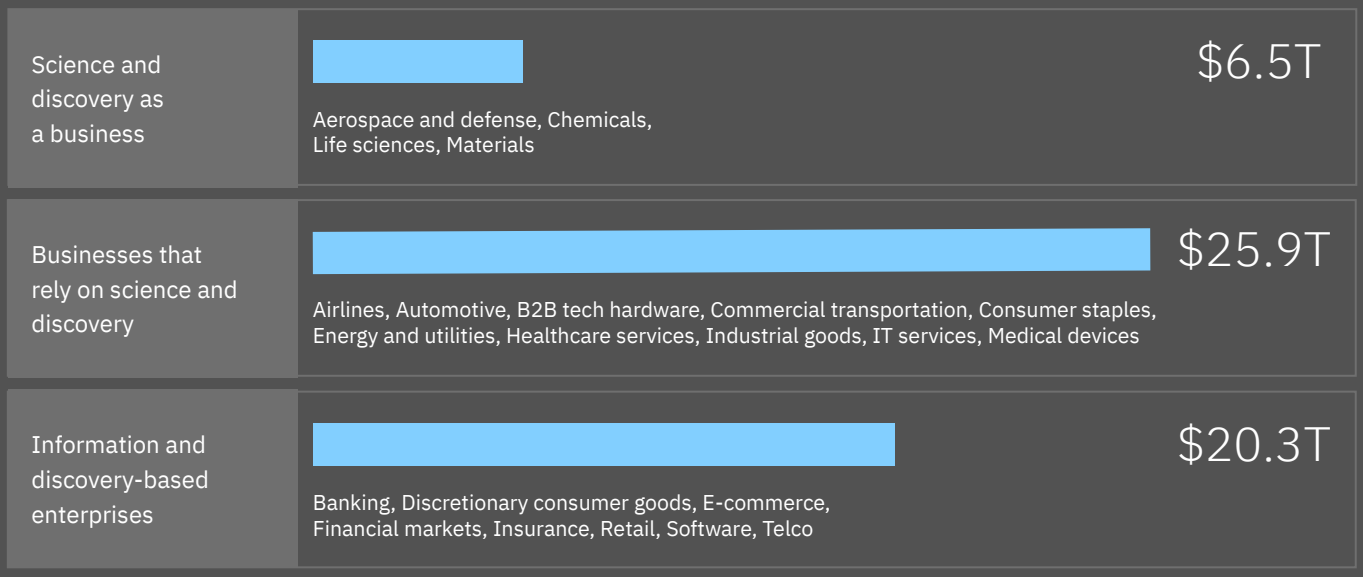
All this can now be executed in real time through ecosystems and Intelligent Workflows, allowing the Virtual Enterprise to identify and mine new value pools faster and better. Data scientists leverage open architectures in the Virtual Enterprise and its ecosystems that multiply the benefits of data sharing, including micro-insights only possible with extreme digitization. Neural networks and other techniques allow decomposition of the most critical and complex problems, facilitating identification of exciting and novel new solutions.

What is science and data-led innovation?

Science and data-led innovation fosters competitive advantage by dynamically and perpetually uncovering new opportunities and solutions. Following the scientific method of experimentation—hypothesize, test, learn—science and data-led innovation taps into both new technologies and the rapidly exploding new data being unleashed by sensors, information sharing, and other connectivity efforts. With an open and rigorous approach, this intersection of data and technology can produce ongoing—and invaluable—process improvements, as well as solutions to previously unanswered questions. Open collaboration is a core facilitator and requirement of science and data-led innovation. Agile development and the IBM Garage approach are great examples of how the power of experimentation is evolving from co-creation to co-execution and co-operation to achieve impact at scale.

Figure 2

Science and discovery drive innovation across industries—and constitute $52 trillion of the $88 trillion world economy



Source: Data and research from Strategic Business Insights, IBM Research; Ward-Foxton, Sally. "Accelerated Discovery: AI and the Scientific Method." EE Times. January 19, 2021. https://www.eetimes.com/accelerated-discovery-ai-and-the-scientific-method/

As AI and machine learning enable ever better pattern recognition, workflow optimization solutions become clearer and more powerful. Cross-industry partnerships and consortia can also be amplified by smart application of scientific methods to drive ecosystem-wide innovations.

Data-led innovation operates at multiple levels in the Virtual Enterprise. It can be at the base level of insights driven from a particular analysis of customer data that prompts the reshaping of a service proposition. It can be within the context of a workflow, where continual monitoring and mining of the activities and performance within a process can highlight areas for improvement and prompt automated or human intervention.

It can also take place at the platform level, where deeper combined opportunities can be imagined from pulling on data sources from across the enterprise and business partners to identify marketplace gaps and product or service innovations. It is in broad ecosystems, however, that the biggest potential for ideation and breakthrough can be seen, where the sheer scale of data, inputs, and participants drives acceleration of not just the idea origination process, but more importantly, the execution and scaling of the inventions. It is for this reason that virtual models and ecosystems will increasingly be the solution to the biggest challenges that we face.

Accelerating discovery via virtualization and openness, integrated communities, and exponential tools

The COVID-19 crisis has changed businesses in profound ways, accelerating the pace of transformation across supply chains, manufacturing, distribution, workforce norms, consumer behavior, and more. This perpetual acceleration requires enterprises to be more agile and responsive than ever. The tools and approaches for managing this new condition are born from science—and will themselves amplify the acceleration.

Many businesses had already begun using analytics and AI to improve business processes prior to the pandemic. Those technologies and a growing focus on examining core enterprise data assets—such as user or transaction data or enterprise workflow patterns—have paved the way to remove, digitize, and automate tasks from production to billing.

Leading organizations are relying on intelligent automation to help reduce costs and improve workflow efficiency. They are building automated AI-powered Intelligent Workflows to balance continuity of operations in response to customer demand. These workflows are embedded with predictive intelligence, such as dynamic customer response, preventive maintenance, and real-time inventory status. This automation enables digitally supported decisions for rapid identification, prioritization, and recommendations for next-best actions. And data from machine sensors and IoT technologies can further enhance workflow automation for real-time insights and predictions.

The Virtual Enterprise takes these practices a step further, tapping into a wealth of external information—whether related to global health or climate or other ecosystem conditions—to guide decisions and adapt its operations and strategy.

Businesses need discovery tools to assimilate information from beyond the core—information on politics, the environment, social moments, and other industries—to protect and extend continuity and resilience. Science and data-led innovation is the instantiation of this process: The rapid collection of data informs decisions, with scientific rigor helping both identify knowledge and manage risk. Executives increasingly recognize the differentiation such innovation can provide, with more than three quarters saying their competitive edge is based on utilizing discovery insights.[1]

The emerging Virtual Enterprise is discovery driven, unlocking value-chain advantage. Science has long been core to sectors such as life sciences, chemicals, and materials. And other businesses rely on the results and outputs of science, such as those in the energy and utilities, healthcare, and technology hardware industries that are propelled by scientific advances in geology, medicine, physics, or other areas.

Today, all enterprises need to become information driven. By applying the scientific method and experimentation at scale—and building on data and AI—they can gain new information about markets and management practices that can drive critical improvements in business strategy, product development, and operations.

What differentiates leaders

What does science and data-led innovation leadership look like? As enterprises become more discovery driven, transformations are required in the areas of culture, skills, business processes, tools, and platforms. For experimentation to be effective, it needs to be performed at scale and in a frictionless manner throughout the organization. A discovery culture is evidence based, which requires adaptivity and openness.

These transformations power enterprise discovery efforts; drive advances in domains such as climate, work, and health; and enable activities in accelerated discovery broadly. Beyond traditional AI tools, enterprises need hybrid cloud platforms to support experimentation at scale. And the injection of quantum computing will open even more new possibilities.

By examining how people work, AI can already help determine the most efficient or effective workflows. Tasks can then be routed to traditional or quantum systems—one or more quantum computers working with a classical computing system—depending on which is the best option. Once information technologists establish a workflow, a user need not know where or how the computation is being done, nor would any specialized knowledge of quantum computing be required.

To make the transformations necessary to cultivate a discovery culture that embraces science and data-led innovation, we suggest a focus on four leadership priorities:

Teamwork: 50% of executives in a recent IBV study cite the ability to collaborate in a team environment as a central workforce capability in a post-pandemic world.[2]

Ecosystem focus: 78% of recently surveyed CTOs say they use discovery-driven mechanisms to identify innovations across their broader ecosystems.[3]

Digitization: Executives predict the percentage of virtual workforce and customer engagement capabilities in their organizations in 2023 will be almost triple the percentage in 2017.[4]

Data advantage: 67% of executives understand the strategic value of data, while 58% access data in real time to create actionable insights.[5]

The Virtual Enterprise embraces these priorities, supporting science and data-led innovation and fueling accelerated discovery. Three key insights form the foundation of this support. They are focused on:

— Virtualization and openness

— Integrated communities

— Exponential tools

Key insight #1

Virtualization and openness enhance discovery across ecosystems

The Virtual Enterprise fundamentally looks outward and forward, leveraging new kinds of data and intelligence.

The Virtual Enterprise unlocks scientific innovation by virtualizing traditional tools for faster and better experimentation, hypotheses, and testing. It relies on open science practices.

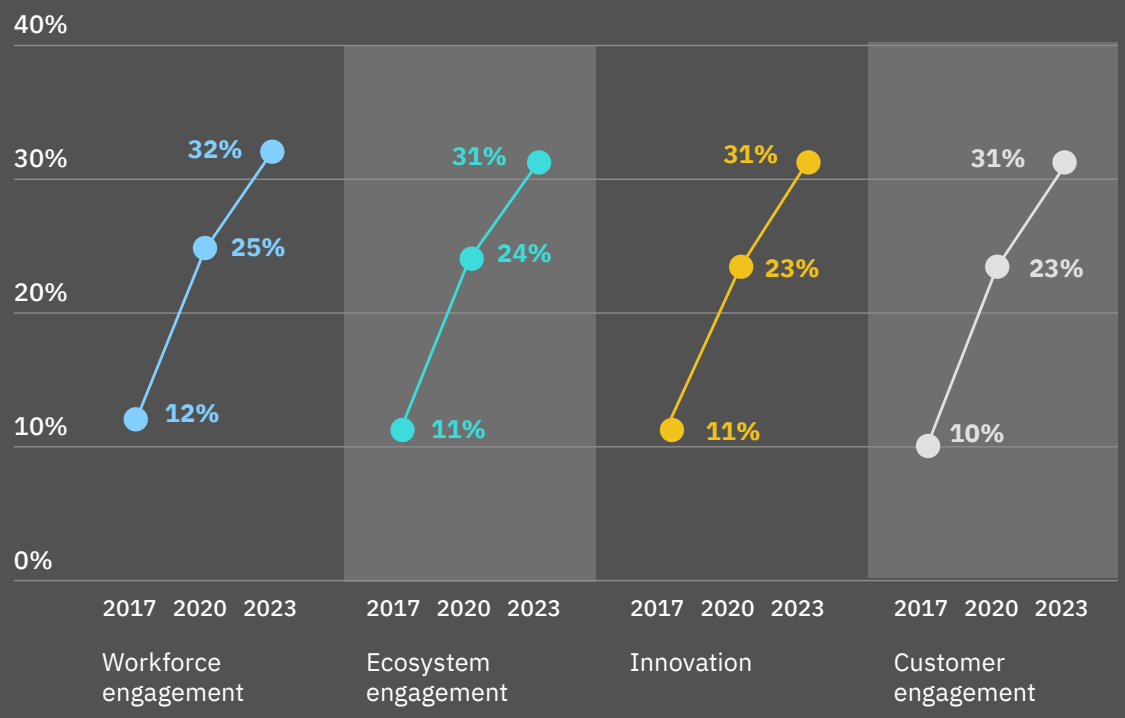
In its earliest days, science was empirical and theoretical. People observed and measured phenomena, such as the motion of objects; made hypotheses and predictions about why they happened; and tested them repeatedly. Computers—and eventually AI and supercomputers—changed that, ushering in the age of analytics. We can now ingest massive amounts of data and develop models for how systems will behave. The Virtual Enterprise redefines traditional infrastructure so that people talent can optimize this capability across the workforce, partnerships, and ecosystems. As 82% of CTOs agree, accelerating the discovery process is central to future growth.[6]

Systems and processes need to be purpose-designed so open collaboration and scientific discovery can emerge. Extended Intelligent Workflows should be digitally fluid—so that one computer, for instance, can be treated by simultaneous users as several independent computers to optimize both agility and security. These advances will make it simpler to define discovery workflows, flexibly manage and deploy them, and enable accelerated scientific discovery at scale. Recognizing these advantages, executives tell us they are increasing their virtualization efforts across functions (see Figure 3).

A hybrid cloud environment can further enhance the discovery process, fostering productivity, collaboration, integration, and scientific reproducibility, while also providing a way to obtain feedback to improve the platform and further grow adoption. There are innovation opportunities across the full hybrid cloud stack, from reimagining middleware—software that sits between the operating system and user applications—to enhancing the way processing gets distributed across computers.

Figure 3

Organizations continue to virtualize a growing number of activities



Source: Previously unpublished data from the 2021 IBM Institute for Business Value Virtual Enterprise Survey.
Q: What percentage of the following activities is/will be virtualized in your organization?

Is your organization looking outward and forward to facilitate accelerated discovery?

Q1 How are you enabling open science practices so your workforce, partnerships, and ecosystems can engage in constant discovery?

Q2 How are you envisioning the evolution of your infrastructure and virtualization efforts so that science and data-led discovery is supported?

Q3 How are you making rapid and ongoing experimentation a core part of your culture?

ExxonMobil

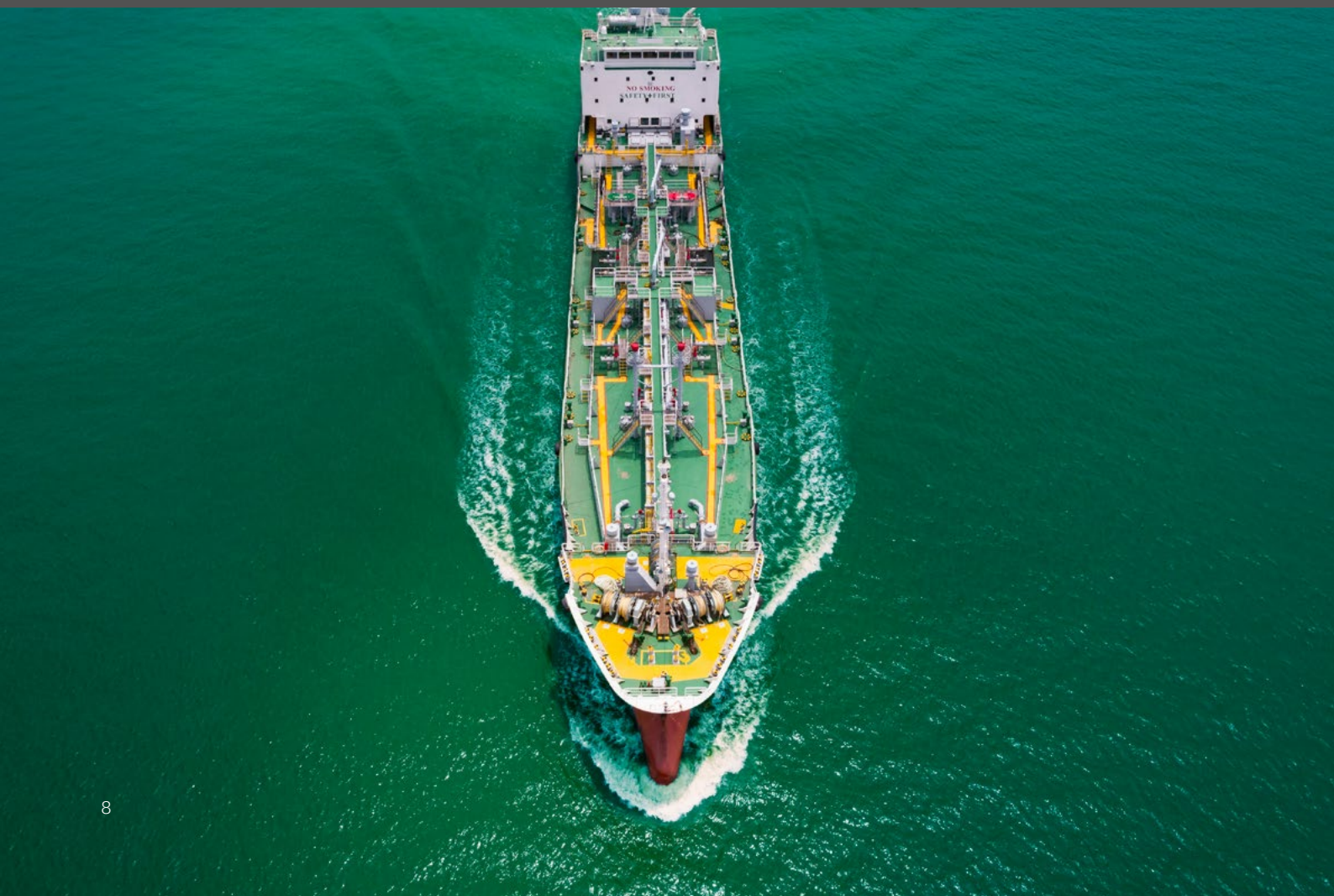
Optimizing global maritime shipping

How do you orchestrate tens of thousands of merchant ships traversing the oceans to deliver massive amounts of consumer goods? Roughly 90% of world trade is dependent upon maritime shipping. More than 50,000 ships, carrying as much as 200,000 containers each, move around every day, transporting goods worth $14 trillion.

On an international scale, optimizing this magnitude of shipping routes is intractable for classical computers. Research teams from ExxonMobil and IBM are using this scenario to investigate how to effectively map optimization problems to quantum computers.

ExxonMobil, in partnership with IBM, is exploring quantum computing algorithms to further tackle the complexities of global shipping. Researchers are applying different strategies to model maritime routing with the ultimate goal of optimizing fleet management. The intent is to calculate journeys that minimize the distance and time traveled by merchant ships across the globe.

The findings benefit not only global shipping, but also extend across ecosystems. Obviously, routing problems are not limited to the shipping industry, and the researchers indicate their findings could easily be transferred to other vehicle optimization problems with time constraints, such as those related to goods delivery, ride-sharing services, or urban waste management.



Key insight #2

Communities of discovery elevate value for all

The Virtual Enterprise applies scientific discovery principles to innovate its enterprise, platforms, and ecosystems, along with its products, services, and business models.

The Virtual Enterprise does not achieve scientific discovery in isolation. More than two-fifths (42%) of organizations expect most of their innovation will flow from open engagement with customers and ecosystem partners over the next 3 years.[7]

Central to that effort are "communities of discovery," which are becoming the new paradigm for the practice and advancement of scientific discovery (see Figure 4). They rely on open science practices and are characterized by dynamic knowledge circulation and well-coordinated collaboration—extended across ecosystems of ecosystems. Such discovery communities are purpose driven, with the impetus for their formation including infrastructure sharing, innovation competitiveness, and a collective mission focus. They operate with portability, elastic capacity, AI-based tools, and security features across multiple clouds.

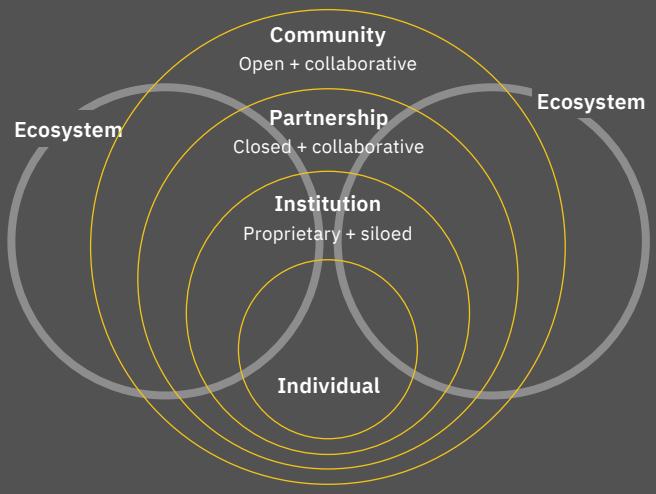
The modern scientific discovery process demands reproducibility of results, collaboration, and effective communication for further expansion. Enterprises cannot remain competitive without leveraging the abundant knowledge, creativity, and resources in these communities. The scientific discovery models practiced there are precursors to the next generation of high-value workflows and workloads.

Leveraging communities of discovery to find solutions to large-scale problems is essential for scaling impact and creating a cycle of accelerated discovery and innovation to positively impact society.

Figure 4

Scaling the scientific method requires communities of discovery

As the size and scope of discovery problems increase, new models of collaboration are imperative to drive innovation and impact of scale



Top 5 workflows conducted or enabled by quantum computing in the next 3 years

Sources: "IBM Science & Technology Outlook 2021." IBM Research; Previously unpublished data from the 2021 IBM Institute for Business Value Virtual Enterprise Survey.

How do communities of discovery fit into your business strategy?

Q1 How are you participating in and encouraging the development of communities of discovery?

Q2 What are you doing to leverage scientific discovery outside your organization, and how openly are you sharing scientific advances and data caches uncovered from within?

Q3 How effectively do your tech systems and cloud processes support collaborative discovery from within and externally?

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, UK, 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 four 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.

Key insight #3

Exponential tools and systems accelerate discovery

New kinds of data and emerging technologies—such as process mining, neural networks, swarm intelligence, and quantum computing—open up entirely new opportunities to accelerate targeted and insight-led experimentation and innovation.

You may recall learning about the basics of the scientific method as a child: a sequence that runs from observation, to question, hypothesis, experiment, results, and finally, conclusion. With classical computing, we've been able to speed up that process.

But as powerful as classical computing is, it has fundamental limitations in the face of exponential problems. Emerging technologies like AI and quantum computing demonstrate enormous potential to accelerate scientific discovery. The Virtual Enterprise embraces these emerging technologies as powerful and essential tools.

Consider the amazing impact of research involving mRNA, a single-stranded RNA molecule that is complementary to one of the DNA strands of a gene.[8] This research expedited COVID-19 vaccine development, from decoding the virus to vaccine creation in only a few weeks and broad vaccine release in a year. This was possible because we had a decade's worth of mRNA research to leverage.[9]

The triad of classical computing, AI, and quantum computing can supercharge experimentation and the scientific method, generating discovery at a radically faster pace (see Figure 5). The unprecedented ability to model complex systems can accelerate the ability to extract, integrate, and validate so that we can draw conclusions. We are already using AI to generate hypotheses automatically and using robotic labs to automate physical experimentation.

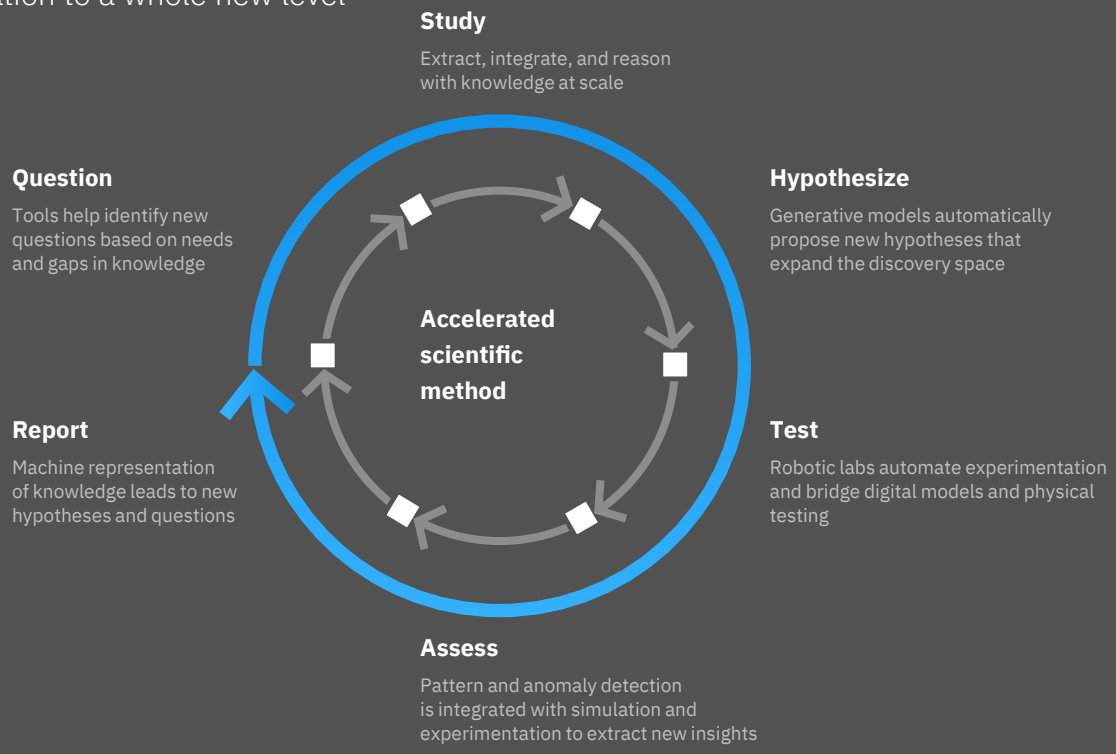
With existing computing, we can model chemical systems, move individual atoms, and simulate how some materials will perform or react over millions of uses. But there are challenges beyond our reach, such as addressing problems where data is unavailable or unclear or imprecise. Quantum computing's step-change capabilities hold the promise of eventually creating solutions to such vexing challenges.

Quantum computers—which are capable of analyzing in minutes problems that would take traditional computers centuries to complete—open the potential to revolutionize areas such as logistics and materials or drug discovery. Quantum-powered workflows and accelerated discovery processes can help the Virtual Enterprise rethink and recast existing workflows entirely, yielding new methodologies, efficiencies, and ways to engage customers, partners, and employees. Extended Intelligent Workflows will be established to offload specific tasks to quantum computers and the innovation that will stem from it.

By *accelerating discovery* and more rapidly translating knowledge into practice, all kinds of new leaps will be possible, from healthcare to finding new materials, to improving the efficiency of solar panels, wind turbines, and battery life.

Figure 5

The combination of classical computing, AI, and quantum computing takes experimentation to a whole new level



Source: "The Quantum Decade: A playbook for achieving awareness, readiness, and advantage." IBM Institute for Business Value. July 2021.

Is your organization equipped to embrace exponential tools?

Q1 How advanced are the scientific tools and data available to your organization, as it looks to accelerate innovation?

Q2 Are you exploring partnerships with exponential technology experts to mesh your organization's insights and information with larger pools and faster tools?

Q3 How well do you understand what quantum computing might bring to your enterprise, industry, partner platforms, and ecosystems?

Cleveland Clinic

Unleashing the potential of cloud, AI, and quantum computing

Nonprofit multispecialty academic medical center Cleveland Clinic, ranked #1 in heart care, is partnering with IBM to establish the Discovery Accelerator, a center that will deploy hybrid cloud, AI, and quantum computing technologies to fundamentally increase the pace of discovery in healthcare and life sciences.

Cleveland Clinic researchers will use advanced computational technology to generate and analyze massive amounts of data to enhance research in genomics, single cell transcriptomics, clinical applications, chemical and drug discovery, and population health—including new approaches to public health threats like the COVID-19 pandemic.

The center will rely on next-generation IBM technologies and innovations like deep search, AI and quantum-enriched simulation, generative models, and AI-driven autonomous labs. As part of the 10-year collaborative program, IBM will provide cloud network access to more than 20 IBM quantum systems, with 1,000+ qubits deployed by 2023.

Action guide

Deploying science and data-led innovation for optimum impact

The Virtual Enterprise can accelerate discovery at an unprecedented pace. The challenges of today's marketplace and today's world are intense. But the tools we have at our disposal are more powerful than ever.

Exponential challenges require exponential capabilities. Embracing those capabilities and integrating purpose-fit processes—relying on experimentation, deploying open science, and leveraging advanced human and technological assets—will help catalyze new solutions. Only through science and data-led innovation will the Virtual Enterprise begin to exhibit its potential.

Here is a six-step outline for deploying science and data-led innovation for maximum impact:

Experiment at scale

- Encourage collaboration and the sharing of new ideas within the organization, with partner networks, and through ecosystems.
- Rely on testing of hypotheses, simulation, and other tools of the scientific method that are core to discovery.
- Develop new and improved data sources through open science methods and practices.

Harness massive data

- Build and replenish clean, clear, reliable information sets, drawn both deeply and broadly.
- Combine predictive and prescriptive analysis for better decision making.
- Look for micro-insights that become possible with extreme digitization.

Architect modern infrastructure

- Leverage open architectures that multiply the benefits of data sharing.
- Deploy AI and machine learning to allow better pattern recognition, workflow optimization, and solution gathering.
- Engage with quantum computing tools and methods to experience expanded capabilities.

Reinforce ecosystem connectivity

- Rely on open, secure hybrid cloud to smooth and speed Extended Intelligent Workflows.
- Join communities of discovery to tap into new ideas and discoveries.
- Prepare guidelines and roadmaps for engagement, information verification, and trust.

Champion science innovation

- Support well-researched solutions, even when surprising or challenging to the organization.
- Invest in ongoing open-ended, but value-based, discovery initiatives.
- Execute on new ideas to scale inventions and innovation.

Embrace the future

- Redefine workforce roles for the discovery-led practices of tomorrow.
- Reorient systemic processes for speed and perpetual change.
- Reimagine where, how, and what your organization can achieve in light of new science and data-led exponential possibilities.

Perspectives from across the field

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Glenn Finch is the Global Managing Partner for Cognitive Business Decision Support. His emphasis on Process Re-Imagination, AI, Data, and IOT is focused on the most challenging and transformative engagements that IBM undertakes. Those engagements have leveraged broader customer centricity, experience, and multiple operations activities across process domains. Glenn has over 25 years of experience with such organizations as ADP, Astra Zeneca, Anthem, State Farm, The Weather Company, Twitter, Unilever, RIMAC, DIRECTV, Banorte, Vodafone, H3G, Maybank, JPMC, HSBC, Bank of America, Capital One, American Express, Citibank, Wells Fargo, Barclays, LTSB, and GE Capital and GM.

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Notes and sources

1 Previously unpublished data from the 2021 IBM Institute for Business Value Chief Technology Officer Study.

2 Previously unpublished data from the 2021 IBM Institute for Business Value Virtual Enterprise Survey.

3 Previously unpublished data from the 2021 IBM Institute for Business Value Chief Technology Officer Study.

4 Institute for Business Value Virtual Enterprise Survey.

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IBM Corporation
New Orchard Road
Armonk, NY 10504

Produced in the United States of America
October 2021

NBJMJLXV-USEN-00