ICTC CTIC

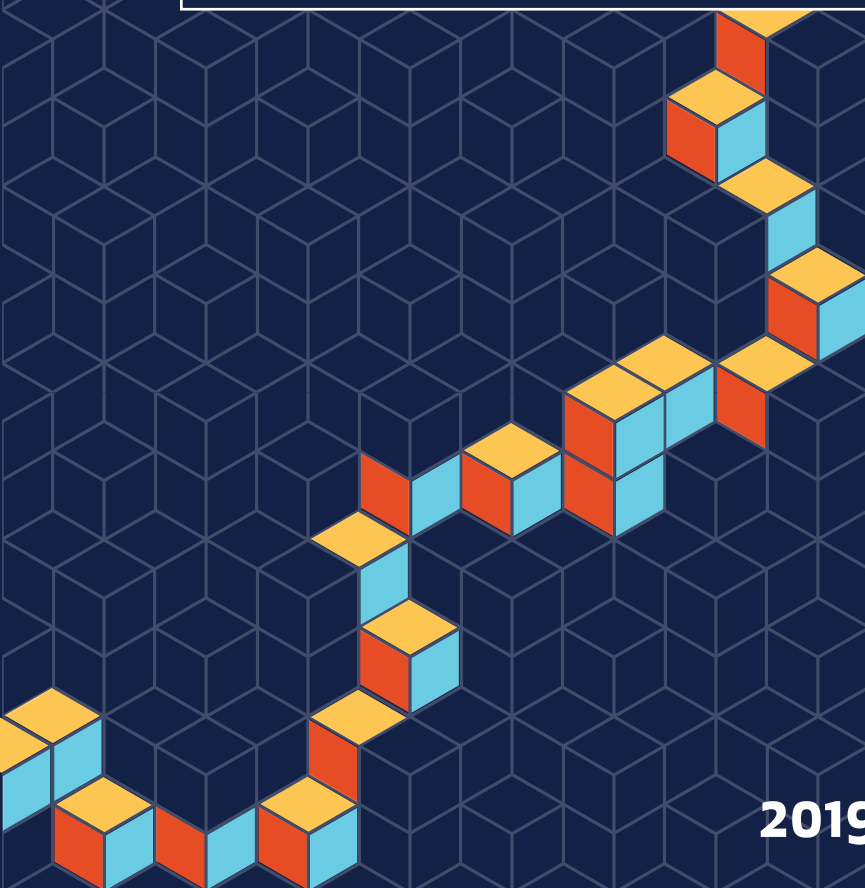# Building Canadian Consensus:
Our Maturing Blockchain Ecosystem

2019

Research by

The Information and Communications
Technology Council

Preface

ICTC is a national centre of expertise for the digital economy. With over 25 years of experience in research and program development related to technology, ICTC has the vision of strengthening Canada's digital advantage in the global economy. Through forward-looking research, evidence-based policy advice, and creative capacity building programs, ICTC fosters innovative and globally competitive Canadian industries, empowered by a talented and diverse workforce.

The opinions and interpretations in this publication are those of the author and do not necessarily reflect those of the Government of Canada.

Acknowledgements

Glossary of Terms

The Glossary of Terms presents an overview of terminology used but not fully expanded upon in the text. For an explanation of important terms such as "Blockchain" or "Smart Contract," please consult the Introduction.

Byzantine fault tolerance (BFT): an important principle for decentralized computing, BFT is a game theory concept referencing multiple parties' ability to act in good faith knowing that there may be one bad actor in their midst. Blockchain consensus mechanisms for public, decentralized systems aim to be Byzantine fault tolerant.

Cryptographic hash function: an algorithm that turns any size of data into a unique fixed-size output and therefore is difficult to invert. This method is used to keep transactions secure.

Decentralized application (DApp): a decentralized computer application running on a computing system that is distributed across many servers (such as Ethereum or Bitcoin).

Delegated Proof of Stake (DPoS): a consensus mechanism (see "proof of work") in which tokens holders vote to select "delegates" or "witnesses" who will validate transactions on a network.

Distributed ledger technology (DLT): a database of transactions that is hosted across a wide variety of servers and locations rather than being controlled and maintained by one centralized authority.

Double spending problem: a potential limitation in digital asset systems where a digital token can be easily duplicated or counterfeited and spent multiple times.

Mining: a process through which new blocks are added to a blockchain, which occurs when one node presents a transaction, it is reviewed by other node(s), and it waits in a queue with other transactions to be published in one "block" onto a Blockchain. Mining nodes are compensated for their time and work for validating and publishing new blocks.

Nodes: People or computers participating in the blockchain are known as egalitarian "nodes" operating within a peer-to-peer (P2P) or decentralized network rather than a centralized server.

Proof of Elapsed Time (PoET): a consensus mechanism (see "proof of work") that imposes randomized wait times on network participants such that the first to run out of time leads the process of adding a new block onto the blockchain.

Proof of Stake (PoS): a consensus mechanism, widely considered to be the most common alternative to proof of work, in which a person validates a percentage of transactions equal to the proportion of tokens they own.

Proof of Work (PoW): the first consensus mechanism, used in Bitcoin, which asks miners to solve a complex computational process, such as finding a cryptographic hash with a specific pattern, whenever they add to the blockchain.

Security token: a security token represents legal ownership of assets that may generate return on investment. The distinction between a security token and a utility token is considered to be important for regulatory purposes.

Smart contract: a smart contract auto-executes the terms of a contract without needing a trusted third party to oversee it. The most developed platform for smart contracts is Ethereum.

Stablecoin: A digital asset with similar features to a cryptocurrency (such as cryptographic protection, P2P exchange, and use of smart contracts) that differs by being backed by assets with a stable price (e.g., the US dollar).

Sybil or 51% attack: an attack on a blockchain made possible when a group of nodes control over 50% of the voting power in a blockchain: either through creating numerous false identities ("Sybil") or by holding over 50% of the network's mining power, computing power, or hash rate.

Utility token: a token that provide users with a (typically in-application) product or service but cannot be exchanged for fiat currency

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Executive Summary

Blockchain is an early-stage emerging technology, and its impact on the Canadian economy and labour market is just beginning to take shape. Building Canadian Consensus undertakes an examination of the Canadian blockchain ecosystem today, documenting its current status and trends for its future. Through in-depth discussions with industry consultants and a wide array of data collection, the Information and Communications Technology Council (ICTC) presents an overview of blockchain technology, the industries it is present in, its applications, and differences across Canada before turning to the labour market and opportunities for studying and working in blockchain. Finally, the report turns to trends over time, examining intellectual property and other data that provides a hint at blockchain's future in Canada and around the world. Overall, Building Canadian Consensus concludes that the Canadian blockchain ecosystem has survived the period commonly known as "crypto-winter," following the dramatical fall in the price of Bitcoin, and now shows signs of maturing through a wide variety of indicators.

Unlike some technologies, an introduction to blockchain as a technology is key to understanding its potential uses and labour market implications. In this paper's first section, ICTC's blockchain backgrounder covers blockchain's history, public and private blockchains, essential terminology, and ends with a commonly used checklist for assessing when blockchain is or is not the right technology for a particular use case.

Although blockchain has a vibrant history in Canada, industry consultants suggest that Canada may be at risk of losing some of this ground due to a conservative investment climate and regulatory uncertainty. In the second section of Building Canadian Consensus, ICTC examines the wide variety of blockchain activity in Canada, primarily through an examination of data on blockchain and cryptocurrency-related companies with Canadian employees. This study finds that the Canadian blockchain ecosystem is comprised of over 280 companies, employing over 1600 workers with blockchain developers, a broad category encompassing many job titles, as well as solutions architects, being the most in-demand blockchain jobs.

Blockchain companies in Canada are predominantly found in finance, fintech, and information and communications technology (ICT). Including cryptocurrency, these sectors represent 56% of all blockchain companies in Canada; however, other sectors, like consulting, along with several emerging sectors—such as the cultural industry and education—are on the rise.

Different regions of Canada also show some distinct patterns with regard to blockchain, particularly in terms of the proportion of blockchain technology versus cryptocurrency activity in each province, but overall data reveals that Toronto and Vancouver comprise the core of the blockchain economy in Canada, responsible for 60% of companies and 65% of total workers. Supporting the growth of this emerging economy, Canada offers a growing array of blockchain education programs, something that sheds light into the overall labour market demand that these programs are teaching to.

Finally, **Building Canadian Consensus** examines time series data showcasing a visible pattern in blockchain-related patents and higher proportions of intellectual property. Combined with the growing average age of start-ups over time, public interest in blockchain, and insights on shifting gender and role composition of the blockchain ecosystem, trends point towards an industry no longer characterized by initial coin offerings (ICOs), but moving slowly and surely towards real value propositions.

While Canada's footprint on the global stage with regard to blockchain may still be relatively small at this point, the country's ecosystem is cautiously finding its feet and beginning the journey from proof-of-concept to production-readiness. Industries such as financial services and fintech may reach this stage first, but a rapidly diversifying set of use cases, combined with increasing familiarity with blockchain on the part of developers, educators, and employers, will see a vibrant ecosystem in years to come.

A Blockchain Backgrounder

> Blockchain represents the second era of the internet. The first era for decades was the internet of information. Now we're getting an internet of value, where anything of value including money, our identities, cultural assets like music, or even a vote can be stored, managed, transacted and moved around in a secure way.
>
> - Don Tapscott, 52 Insights, April 2018[1]

What is Blockchain?

Blockchain, the innovation that famously enabled Bitcoin, has rapidly become a key emerging technology with implications for a diversity of sectors, including but exceeding cryptocurrencies and fintech. Despite its increasing popularity, blockchain technology remains difficult to define for the non-specialist, both in terms of the unique technical components at the core of the technology, and the widespread imprecise usage of the term. The following section provides an introductory discussion of what blockchain is and what key concepts guide its use in Canada today.

Bitcoin and the Beginnings of Blockchain

In 2008, a person or collective using the pseudonym Satoshi Nakamoto published "Bitcoin: A Peer-to-Peer Electronic Cash System." This document proposed the first iteration of blockchain as the underlying technology behind Bitcoin, widely regarded as the first effective cryptocurrency. Blockchain and Bitcoin solved the double spending problem, a core issue for digital currencies without a centralized authority. Blockchain uses several key innovations (rooted both in cryptography and in game theory or mechanism design) to prevent users from duplicating or falsifying online assets without needing to go through a bank or government. Several of these core concepts are discussed below.

[1]Don Tapscott, "Blockchain represents the second era of the internet" 52 Insights, April 5, 2018, https://www.52-insights.com/don-tapscott-blockchain-represents-the-second-era-of-the-internet-interview/

Blockchain: A Distributed Ledger

In simple terms, a blockchain is a type of distributed ledger technology (DLT) that is continually updated by participating users and verified by other users, hosted across numerous servers rather than having a single authoritative version held by a single user or data center. Everything entered into the blockchain is permanently recorded: a writer can create a new entry that reflects the change of a previous record, but they are never able to delete an entry.[2] The integrity of entries in the blockchain is maintained through a cryptographic hash function, and blockchain uses a particular cryptographic technique where each entry or "block" is encoded such that it points back to the previous block, meaning that no old entry can be changed without compromising all the other blocks in the interlinked "chain."[3] Using this basic process, blockchain is intended to be decentralized, transparent, open-source, autonomous, immutable, and pseudonymous.[4]

Figure 1: *What is Blockchain?*
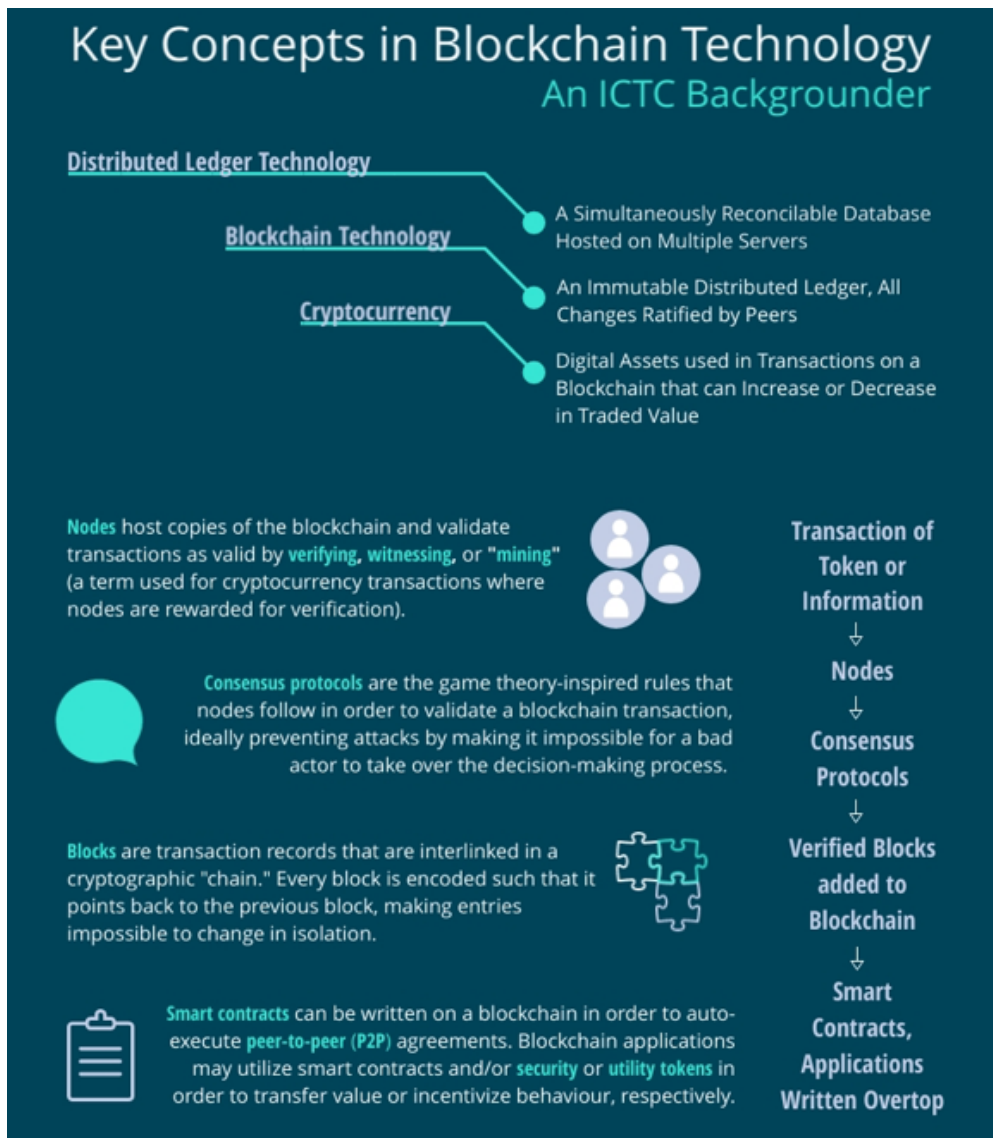
[2]Lou Carlozo, "What is blockchain?", Journal of Accountancy Vol. 224, no. 1, 2017, p. 1.
[3]Emily Kotow, "What is Blockchain Hashing?", Hedgetrade, February 26, 2019, https://hedgetrade.com/what-is-blockchain-hashing/
[4]Ion-Chang Lin and Tzu-Chun Liao, "A Survey of Blockchain Security Issues and Challenges," International Journal of Network Security, Vo. 19, no. 5, 2017, pp. 653-659.

Blockchain's Key Concepts

Nodes, Miners, and Verification

As described in Figure 1, participants in the blockchain process, or nodes, host copies of the blockchain and/or verify transactions that occur on the blockchain, the latter of which is known as "mining" with respect to Bitcoin but could also be called "witness-ing" or "validating." Nodes validate transactions that are occurring for the first time and have the correct timestamp (i.e., the same transaction has not occurred twice). Finally, transactions are verified in a combined block through a pre-established consensus protocol, and each block includes a cryptographic hash of the previous, a timestamp, and transaction information. Thus, the blocks form an ever-growing, inter-reliant chain, making it difficult or even impossible to alter any piece of it without alerting honest nodes.

Consensus Mechanisms

Since 2008, blockchain's core concepts have been adapted for cryptocurrencies other than Bitcoin, as well as numerous non-cryptocurrency applications. A consensus mech-anism establishes the rules of communication and validation discussed above; they are essential to guaranteeing that a blockchain is secure. For example, one way to corrupt the blockchain process and falsify a transaction would be to generate numerous IP ad-dresses as fake identities, collectively overpower the honest nodes, and add an incor-rect transaction in a Sybil or 51% attack. Several types of consensus mechanisms have been invented to prevent this problem from occurring.

Bitcoin uses a consensus mechanism known as Proof of Work (PoW), which asks miners to solve a complex computational process (like finding a cryptographic hash with a spe-cific pattern) whenever they alter the blockchain. PoW changes "one-IP-address-one-vote" to "one-CPU-one-vote," making it more difficult for an attacker to harness enough CPU power to outweigh the majority of honest nodes. Bitcoin miners are incentivized to participate in this process by being rewarded with Bitcoin and transaction fees; thus, code and incentives work in tandem to create a trust-free system that in theory does not require an overseer.

A common criticism of the PoW mechanism is that it consumes significant energy to continually and competitively solve computational challenges. A popularly cited figure estimates that the Bitcoin mining community's electricity use in March 2018 was com-parable to that of the entire country of Ireland.

[7]Excluding the ICT sector, which cuts across all innovation areas.
[8]James Manyika, Susan Lund, Michael Chui, Jacques Bughin, Jonathan Woetzel, Parul Batra, Ryan Ko, Saurabh Sanghvi, "Jobs lost, jobs gained: What the future of work will mean for jobs, skills, and wages", McKinsey Global Institute, November 2017.
https://www.mckinsey.com/featured-insights/future-of-work/jobs-lost-jobs-gained-what-the-future-of-work-will-mean-for-jobs-skills-and-wages.
[9]Alexandra Cutean, Robert Davidson, "Mapping Calgary's Digital Future: Tech Employment Opportunities for Displaced Workers"
Information and Communications Technology Council, August 2018. https://www.calgaryeconomicdevelopment.com/dmsdocument/252
[10]Terra Ciolfe, "What the census tells us about Canada's aging population" MacLean's, may 3, 2017.
https://www.macleans.ca/news/canada/what-the-census-tells-us-about-canadas-aging-population/
[11]Myriam Hazel, "Labour Statistics at a Glance: Reasons for working at 60 and beyond", Statistics Canada, December 14, 2018.
https://www150.statcan.gc.ca/n1/pub/71-222-x/71-222-x2018003-eng.htm

As such, other consensus mechanisms have been produced; at the time of writing, the most-cited alternative to PoW is Proof of Stake (PoS). In PoS, attacking the network is thought to be disadvantageous for those miners who hold greater stakes because it would likely lead to a fall in the value of their own currency : As such, a user with a higher "stake" in a currency's success is expected to make decisions that are most advantageous for the success of the platform. Alternate consensus mechanisms such as Proof of Elapsed Time, Delegated PoS (DPoS), and other Byzantine fault tolerant (BFT) variants are used by a variety of blockchain technologies. For example, Facebook designed its own protocol, LibraBFT, for the Libra cryptocurrency project.

A New Canadian Consensus

Jonathan Baha'i of Peerplays Blockchain Standards Association (PBSA; Nova Scotia) is recommending a new consensus mechanism, designed by PBSA, in late autumn 2019. The Peerplays blockchain is currently using delegated proof-of-stake (DPoS), and PBSA is recommending switching over to a new protocol due to some flaws they see in the DPoS incentive structure that affect the overall security of the blockchain:

> GPoS, or gamified proof-of-stake, is our own consensus mechanism, which we've designed. In DPoS, the security of the network is completely predicated on the token holders' participation in voting. No matter what space you're in, voting always suffers from a low turnout. It's not properly aligned with the right incentives. In addition to that, if core tokens are being traded on centralized exchanges they become a security risk, because those exchanges can use the tokens in their custody to vote on the blockchain. Accordingly, instead of simply delegating the proof of stake, we're gamifying the process of voting by adding incentives, and our first iteration of this will be operational soon.

Over time, Baha'i sees GPoS gaining traction as a way to let members of decentralized cooperatives know that their votes count, removing objections that smaller token-holders may have to other versions of PoS.

Permissioned and Permissionless Blockchains: Platforms and Protocols

Blockchains can be entirely open or restrict the users who have access to them. The term "blockchain" is somewhat contested for projects that integrate permissioned systems, with some industry participants arguing that DLT is a better term for systems that are not public. Blockchain's current proliferation of platforms has been identified as a problem by some in the industry, with Gartner reporting that 90% of all blockchain platform implementations will need to be replaced by 2021 to avoid obsolescence given the fragmented state of the solutions available.

PERMISSIONLESS

Bitcoin and many
Ethereum applications

PUBLIC ← → PRIVATE

Often appropriate for
public sector use cases

Hyperledger Fabric in
many applications
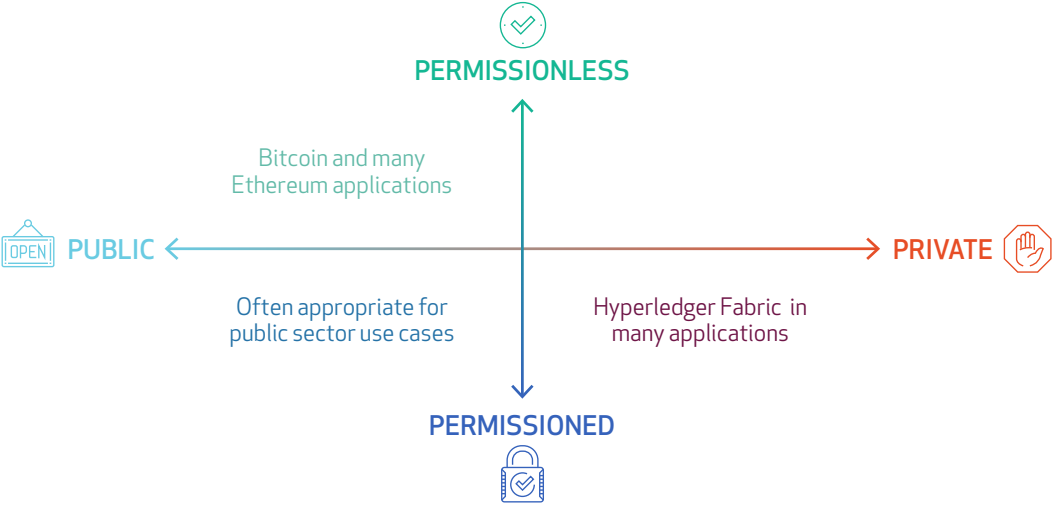
PERMISSIONED

Public/Permissionless

Examples: Bitcoin, many applications of Ethereum

A public blockchain is open such that any person can participate as a user or node miner. A person becomes a user by downloading the code and participating in the public consensus by validating transactions. In a public blockchain, everyone is pseudonymous and transactions therefore depend on the blockchain protocol rather than on trust in other users or nodes. In 2019, 45% of global executives surveyed by Deloitte said that they were focusing their activities, non-exclusively, on a "public blockchain like Bitcoin or Ethereum."

Public/Permissioned

Examples: Often appropriate for public sector use cases

A public blockchain that anyone can read can also be designed such that write access is permissioned.

Private/Permissioned

Examples: Hyperledger Fabric (by the Linux Foundation) in many applications

In a private blockchain, use is permissioned and controlled by a central leader node: whitelisted participants are allowed access, and these participants are likely known with trusted identities. This improves overall security and allows decision-making without the need for costly consensus protocols such as Proof of Work. However, the need for a central authority to determine who qualifies as a permissioned user makes private blockchains a topic of debate. About half of global executives in Deloitte's 2019 survey noted that they were focusing on private or permissioned blockchain models.

Federated/Permissioned

Examples: Many Hyperledger, Corda, and Quorum applications, Libra (proposed), Aion Network

The term "Federated" blockchain, also sometimes known as "Consortium" blockchain, is used in several different ways. The first involves a number of pre-selected leader nodes collaborating to verify transactions, where no single node has overall authority. For example, the banking industry might adopt federated distributed ledgers to be able to operate cross-industry, interoperable record-keeping. Federated blockchains reduce data redundancy, improve efficiency of communication, and are easily scalable. In 2019, 29% of global executives reported that they were exploring consortium blockchains. Federated can also refer to efforts to make different types of blockchains interoperable, such as Canada's Aion Network, whose protocol connects other types of protocols together in a "hub and spoke" model.

Smart Contracts

Central to numerous use cases for blockchain, a **smart contract**[25] executes the terms of a contract without needing a trusted third party to oversee it. In the context of blockchain, a smart contract executes a contract through pre-ordained code and removes the need to trust a government or financial institution.[26] Smart contracts have a variety of vulnerabilities, including the need to assess quality of a product before the contract is executed and the potential for bugs in code that cannot be removed once established.[27] However, smart contracts are the core concept behind numerous blockchain applications (sometimes referred to as **decentralized applications** or DApps) and they often utilize **security tokens** or **utility tokens** to transfer digital assets that may generate ROI or incentivize particular behaviours, respectively.

Cryptocurrency and Blockchain: Related but Separate Worlds

While some companies participate in both the cryptocurrency and blockchain worlds, industry consultants who contributed to this study frequently identified either as "blockchain" or "crypto" and noted that they had different priorities, saw different trends, and were experiencing different labour market and regulatory pressures.

> I like to distinguish blockchain and Bitcoin, but I can talk about both. I think that blockchain is being overvalued, but that the Bitcoin ecosystem in Canada is really advanced compared to other countries.
>
> - Maciej Cepnik, Veriphi

> We're more in the identity space so we don't have the securities/crypto concerns that other blockchain orgs have. It's all in the token space, in its own ecosystem. There's a big distinction, philosophically, motivationally, and culturally. Even though they both leverage blockchain they're very different worlds.
>
> - Alex Todd, ReliablyME

However, some interviewees noted that this division might have emerged due to several cryptocurrency-related scandals in Canada, and that as "bad actors" were slowly rooted out by regulation and time, this division would heal itself. The movement towards private, token-free blockchains may have come from the same source, such that public blockchains may see a resurgence if cryptocurrencies successfully repair their public image.

While this report primarily focuses on blockchain and non-cryptocurrency related use cases, data related to cryptocurrency companies and several related trends are also presented throughout.

[25]Nick Szabo, "Smart Contracts," 1994,
http://www.fon.hum.uva.nl/rob/Courses/InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/smart.contracts.html
[26]Szabo, 1994.
[27]Nicolai Aztei, Massimo Bartoletti, and Tiziana Cimoli, "A Survey of Attacks on Ethereum Smart Contracts (SoK)"
Proceedings of the 6th International Conference on Principles of Security and Trust Vol. 10204, pp. 164-186, April 22-29, 2017.

When is blockchain the right solution?

> Why do we use blockchain? It is fundamentally that we don't have to be a trusted third party when people send us their data. It's proof that we're walking our talk, which is fundamental to our brand promise that we're allowing people to control their own credentials. In our case we're saying the technology is behind it, assuring that we're not storing your data.
>
> – Alex Todd, ReliablyME

In the sections that follow, industry snapshots and existing Canadian applications will provide an overview of useful blockchain implementations. However, several studies have begun to identify the key elements that underpin a useful blockchain application.[28] Some key questions for any organization exploring blockchain include:

- Do we need to permanently store data?

- If yes, do we need more than one author or writer of the data?

- If yes, do the writers have mutual trust?

- If no, do we have consistent access to a trusted authority or third party whose services we are happy with and can oversee data or transaction quality?[29]

Importantly, an organization that has no issues with regard to mutual trust and consensus between its writers may still choose a private or federated distributed ledger instead of a solution like a cloud-based database in a VPN, highlighting the importance of the differences between "public" and "private/permissioned"-type blockchain solutions. In other words, an evaluation of blockchain's usefulness should consider its cornerstone offerings: trust, consensus, and immutability, as well as the permissions or decentralized principles particular to different organizations' needs.[30]

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[28]For example, Sin Kuang Lo, Xiwei Xu, Yin Kia Chiam, & Qinghua Lu, 2017. "Evaluating suitability of applying blockchain."
Proceedings of the 22nd IEEE International Conference on Engineering of Complex Computer Systems, ICECCS, pp. 158–161, Nov 5-8 2017.
[29]*Karl Wüst and Arthur Gervais. "Do you need a Blockchain?"*
Proceedings of the 2018 Crypto Valley Conference on Blockchain Technology (CVCBT) 20-22 June 2018.
[30]*Kaspars Zīle and Renāte Strazdiņa, "Blockchain Use Cases and Their Feasibility," Applied Computer Systems, 2018 (23), no. 1, pp. 12-20: 16*

When is blockchain *not* the right solution?

Like all new technologies, the overall change-making potential of blockchain is yet to be determined.[31] Even if blockchain does not truly *revolutionize* the world as we know it, the technology will undoubtedly have a substantial impact in key areas. Blockchain is unlikely to be the panacea to every challenge and inefficiency we see today; and its applications may be best suited for certain applications. This section discusses several ongoing challenges for and criticisms of blockchain technology.

The most potent criticism of blockchain today is that it frequently comprises an over-complication of a businesses' needs. As alluded to in the previous section, there are many use cases for which a well-designed, real-time, editable, centrally managed database with multiple writers is a simpler solution than blockchain. Coupled with issues of legacy system integration, which will be addressed in the third section, blockchain is not the most efficient data management choice for many businesses.

Second, use cases involving Bitcoin and other PoW mechanisms continue to struggle with scalability, due to its energy-intensive design. Despite its continued popularity and seminal contribution, Bitcoin faces not only an exorbitant energy-use problem (recently compared to the total energy consumption of the Czech Republic)[32] but also fluctuating transaction fees and transaction processing times, making it unsuitable for microtransactions. While other consensus mechanisms are in development and attempting to solve these issues, their full implementation in production-ready use cases are yet to be fully tested.

Finally, and again in reference to the previous section, there are a wide variety of effective trust mechanisms already in place in human organizations that remain the default, particularly in Canada. Blockchain may be a powerful tool for achieving trust between anonymous parties like players in a supply chain or sensors in an IoT network. However, transactions occurring between parties that exist within a longstanding relationship (or an understood set of norms) probably do not need blockchain to maintain trust. An employee trusts that their employer will continue to pay them twice per month, because both parties wish to maintain a mutually beneficial relationship and honest reputations. Human beings have engaged in commerce for millennia using social capital, and blockchain's promise to engineer away the need for trust is accordingly a fruitful area of debate.

[31]Kasey Panetta. 5 Trends Emerge in the Gartner Hype Cycle for Emerging Technologies, 2018, August 16, 2018. https://www.gartner.com/smarterwithgartner/5-trends-emerge-in-gartner-hype-cycle-for-emerging-technologies-2018/
[32]Umair Irfan, "Bitcoin is an energy hog. Where is all that electricity coming from?", Vox, June 18, 2019. https://www.vox.com/2019/6/18/18642645/Bitcoin-energy-price-renewable-china

The Ecosystem Today

Existing research has acknowledged Canada as a mid-level player in the global block-chain ecosystem: as a country, we are no longer leading the way in blockchain innovation; however, our legacy with Ethereum as well as new and noteworthy research and development in hubs across the country mean that we are also by no means at the back of the line. Figure 2 provides a qualitative overview of blockchain's recent history in Canada, from the very beginnings of Bitcoin to the current era of enterprise innovation and startup scale-up. Trends over time showcase the proportion of blockchain and cryptocurrency-related startups founded each year, illustrating the boom and bust associated with the price of Bitcoin and other currencies.

Figure 2 does not forecast startups in 2019 and beyond, but it illustrates the current Canadian context and sets the stage for further description of trends over time and predictions for the future.

Figure 2: A brief history of blockchain in Canada
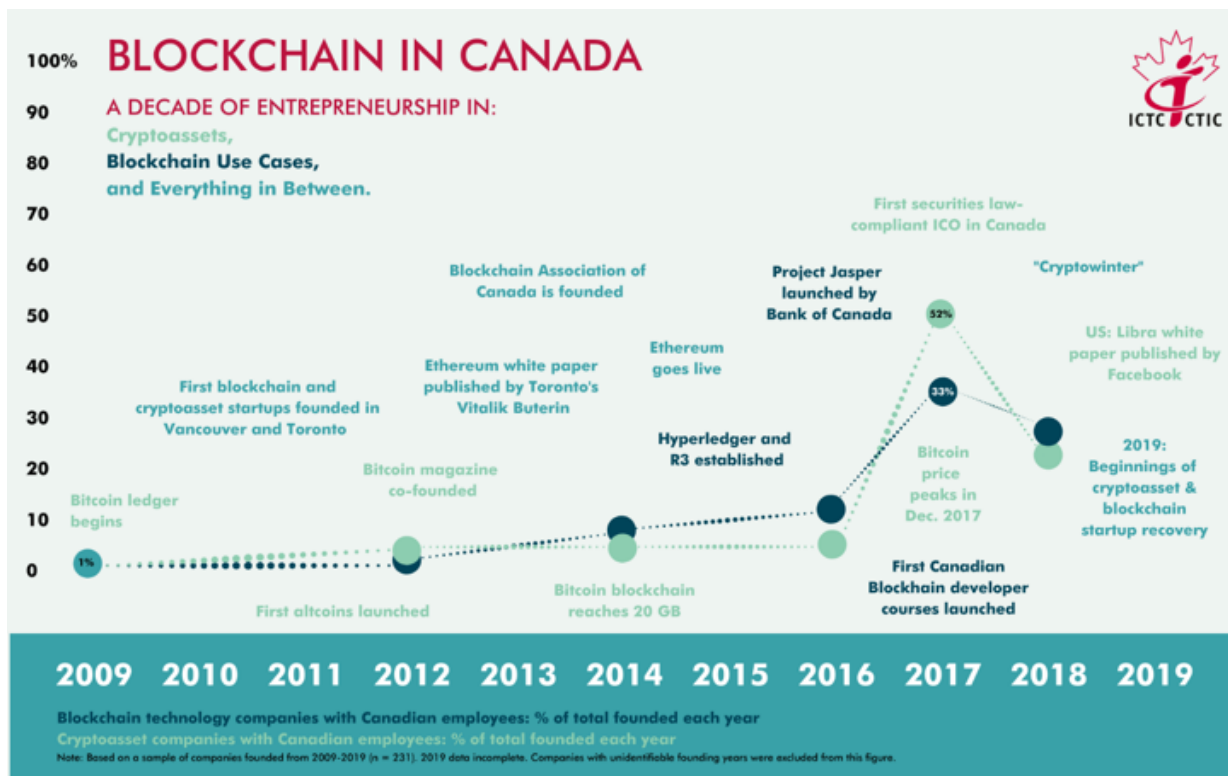
Several noteworthy studies have made key observations about blockchain's progress in Canada, observations which are supported by ICTC's consultations with industry representatives.

When predicting their companies' future investments in blockchain, Canadian executives show a significant level of interest, but remain risk-averse.

In other words, there are many companies interested in and familiar with blockchain, more than in many other countries, but few who are staking significant investment dollars on this technology. Deloitte's 2019 Global Blockchain Survey included 103 Canadian senior executives, representing mostly large companies where just over half (52%) had annual revenues over $1Bn USD.[33] The vast majority, 87%, felt that their company would invest in blockchain in the next 12 months, with over half (54%) estimating that they would spend over $1 Million USD, and 8% estimating $10 million or more, a smaller proportion than every other featured country with the exception of Hong Kong.[34] ICTC interviewees confirmed that Canadian investors and businesses tended to exercise caution and moderation in their investment choices, and that this conservative approach had not helped encourage start-ups to sell to Canadian clients. As one respondent commented, "for every $1 of business you can do in Canada, you can do $100 in the US or $100,000 in China."

The Canadian regulatory environment has had an impact on business.

Effective regulation for blockchain, cryptocurrencies, and tokenized platforms is a complex debate. Several countries have begun to move towards holistic regulations, such as Liechtenstein's "Blockchain Act," which addresses ownership, transfer, and storage of digital assets, as well as licensing and relationships with existing securities regulations (such ask KYC and AML requirements), treating tokens as a representation of certain rights (e.g., to a security or to IP).[35] Currently, Canada is in the midst of conversations on token economy regulation, and the Canadian Securities Administrators (CSA) has named addressing blockchain as one of and its strategic business goals for 2019-2022.[36] While blockchain-related policy is being determined, several industry consultants noted that regulatory uncertainty has disincentivized several blockchain companies from staying in Canada, including noteworthies like Ethereum.

[33]*The survey included 12 countries in North America, South America, Europe, and Asia. Deloitte, 2019, p. 19.*
[34]*In comparison, 41%, 33%, and 31% of Luxembourg (n = 51); Switzerland (n = 52); and Germany (n = 131) pledged over $10 million, respectively, and only Hong Kong (n = 101) had a smaller proportion of high investment estimates than Canada, at 6%. Deloitte, 2019, p. 22.*
[35]*Baker McKenzie, "Liechtenstein Government Announces New Blockchain Act," Lexoloy, June 10, 2019, https://www.lexology.com/library/detail.aspx?g=b489204a-3d38-4571-9aa3-4a4e0317f151*
[36]*Canadian Securities Administrators, "CSA Business Plan, 2019-2022," May 28, 2019, https://www.securities-administrators.ca/uploadedFiles/General/pdfs/CSA_Business_Plan_2019-2022.pdf*

Governments within Canada are beginning to incorporate blockchain into the public sector, at a competitive pace.

The OECD reports that Canada had 8 uses of blockchain in the public sector as of March 2018, placing it in the top 10 of nearly 50 countries analyzed.[37] Since the OECD study, Canada has announced that it intends to involve blockchain technology and AI in digital transformation within government departments, through its Policy on Service and Digital, effective April 2020.[38] Provincial governments in Canada are also beginning to explore blockchain, such as a Government of British Columbia project, OrgBook BC, which has taken inspiration from blockchain technology to create a verifiable identity and registration management service.[39]

Canada has highly skilled blockchain talent, but also has a high degree of existing trust in institutions of governance and finance. Several industry representatives consulted in this study characterized Canada as a high-skilled incubator for blockchain technologies and personnel: Canadian users will likely begin to adopt blockchain out of convenience rather than need, due to a reasonable degree of trust in existing financial and governing infrastructure.[40] As such, the country can position itself as an important player in developing meaningful, globally scalable applications, but until blockchain technologies become more user-friendly—as they are beginning to with some user applications where clients are not even aware that blockchain is the underlying technology—many deem it unlikely that the average Canadian user will feel an urgent need to turn to blockchain.

> Too many blockchain companies are building for convenience-based consumers, but in other markets and countries where most people don't even have bank accounts, blockchain is need-based rather than convenience-based. So that's where you see the opportunity for Canada to really capitalize and to ignite mass adoption—to develop a product that is both technologically sound and actually implementable to addresses barriers in emerging markets.
>
> - Lucia Gallardo, Emerge

As an emerging technology with a vibrant community of contributors, blockchain cannot be measured solely through investment or uptake, however. In what follows, ICTC examines the blockchain ecosystem through several lenses: through industry and use case snapshots; across different regions of Canada; and through training and the labour market. This section is informed by a synthesis of engagements with over 30 industry consultants,[41] existing data on blockchain in Canada, and an ICTC dataset on blockchain companies that hire Canadian employees.

[37]Jamie Berryhill, Théo Bourgery, and Angela Hanson, "Blockchains Unchained: Blockchain Technology and its use in the Public Sector, OECD Working Papers on Public Governance, No. 28, 2018, OECD Publishing, Paris. http://dx.doi.org/10.1787/3c32c429-en
[38]Policy on Service, Government of Canada, Aug 2, 2019, https://www.tbs-sct.gc.ca/pol/doc-eng.aspx?id=27916. ISBN: 978-0-660-09949-1
[40]For further information, visit "OrgBook BC: Public Beta" on the Government of British Columbia website at https://orgbook.gov.bc.ca/en/home
[41]For example, in the Edelman Global Trust Index, Canada was ranked slightly higher than the global average in 2019 (56% in Canada vs. 52% based on a sample of 26 countries for the general population). 2019 Edelman Trust Barometer Global Report, p. 6, https://www.edelman.com/sites/g/files/aatuss191/files/2019-03/2019_Edelman_Trust_Barometer_Global_Report.pdf
[41]Consult Appendix I for details on the study's qualitative methodology.

The Voices of Canada's Blockchain Ecosystem: Industry Consultations

ICTC was supported in its project by over 30 members of Canada's blockchain and cryptocurrency communities, through a combination of 24 in-depth interviews and two additional group discussions of preliminary findings in the form of focus-group-style Advisory Committee meetings. Due to the emergent nature of blockchain both as a topic and as a technology, industry consultations were an invaluable component of this research.

Pathways into Blockchain

Many of the industry representatives consulted by ICTC were successful entrepreneurs or technology and consulting professionals who pivoted to blockchain when they discovered the concept: at a conference, through a news article, through a Wired video, or at a Meetup, among other chance circumstances. Others work within large enterprises that recognized the importance of developing blockchain expertise to remain leaders in their sectors. Industry members more involved in cryptocurrencies often discovered the ecosystem through their first investments in Bitcoin, and some have remained squarely in cryptocurrency services, while others have branched out into other uses of blockchain technology.

Sector, Type of Organization, and Size

As illustrated in Figure 3, ICTC's interviewees and focus groups represented a broad diversity of organizations, from pre-revenue start-ups to large enterprises and not-for-profits or educators. Most interviewees belonged to organizations that were relatively small, with approximately one third of participants (30%) coming from enterprises of over 500 people. The dearth of medium-sized enterprises may be attributed to blockchain's early stages as a technology: while existing large enterprises might have begun to adopt blockchain, few dedicated blockchain start-ups have had time to scale up to 100+ employees in Canada.

Industry consultants represented a wide variety of sectors and blockchain use cases, as also illustrated in Figure 3. In addition, they were selected to lend voices from across the country, in particular Nova Scotia, Quebec, Ontario, Saskatchewan, Alberta, and British Columbia.

Interview, Consultation, and Focus Group Participants

Figure 3a: *Type of Organization**

Partnership — 3.0%

Government Agency — 3.0%

Public Company — 6.1%

Higher Education — 15.2%

Not-for-profit — 15.2%

57.6% Privately held

Categories from LinkedIn

Figure 3b: *Size of Organization*

Very large 10,000+ — 9.1%

Large 500–9,999 — 21.2%

Very small 0–9 — 36.4%

Small 10–99 — 33.3%
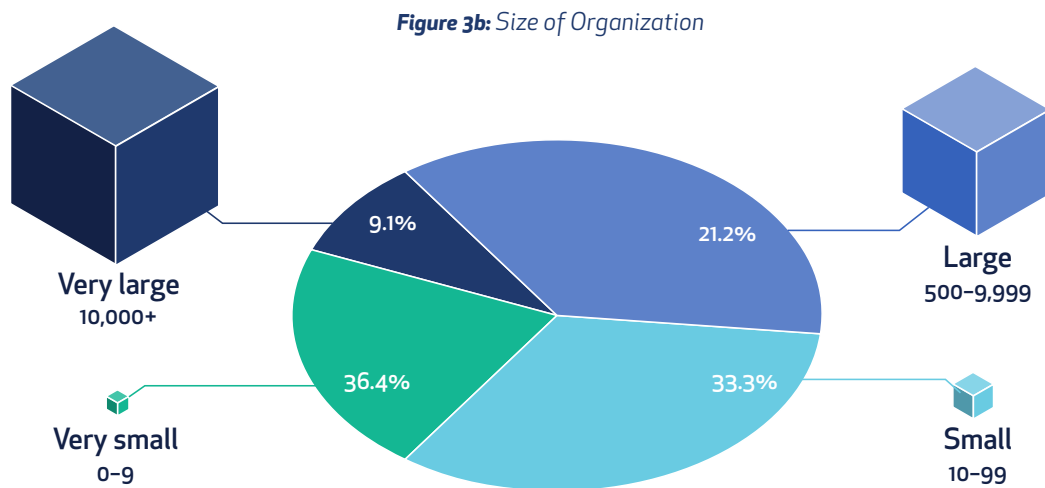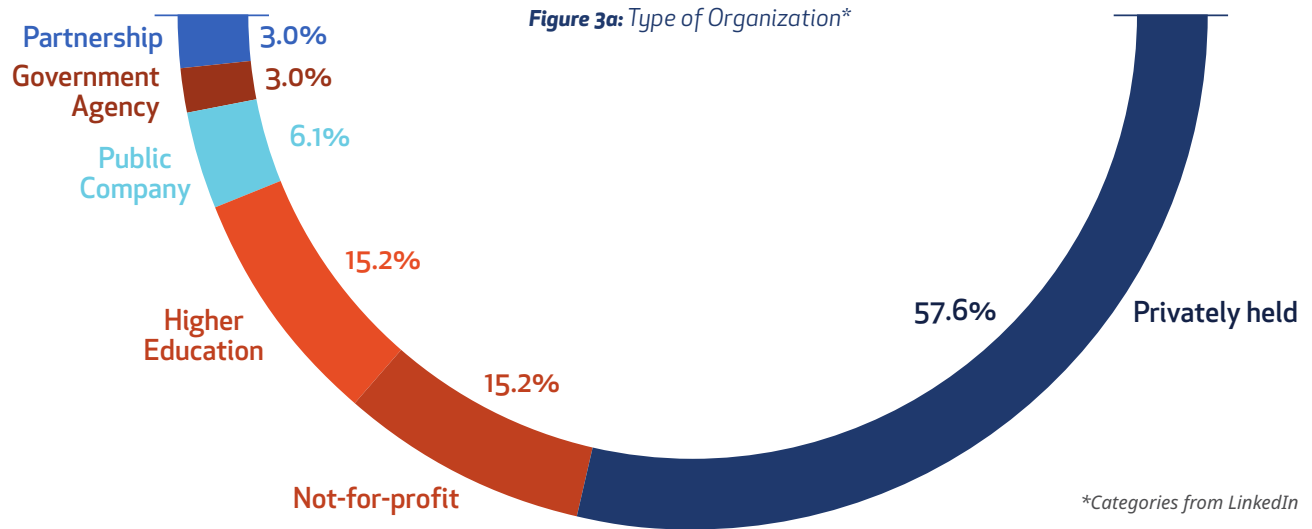
Figure 3c: *Represented Sectors*

- Consulting: Blockchain Adoption, Talent, Investment, and Legal
- Education: Post-Secondary and Certificate
- Energy, Environment, and Utilities
- Entertainment, Media, and Gaming
- Finance, Fintech, and Cryptocurrency
- ICT and Computer Software
- Identity and Credential Management
- Industry Associations and Consortia
- Retail and Consumer
- Supply Chain Management

Source: ICTC

Blockchain in-use in Canada:
Industry and Use Case Snapshots

In Canada and around the world, blockchain's novel properties of distributed data hosting, traceability, and immutability have sparked a wide variety of ideas for use cases. The same concepts that enable cryptocurrencies support other financial applications: for example, a smart contract could allow two peers without mutual trust to place a wager without requiring a middleman, and blockchain as a distributed ledger can facilitate interbank payments and securities settlement, as demonstrated by the Canadian Project Jasper.[42] Beyond financial applications, blockchain's potential to support interoperability between otherwise closed-loop systems and to avoid centralized storage and ownership of personal data, among many other potential applications, has implications for digital identity and data management, supply-chain management, digital media, healthcare, e-government, and beyond.

Canadian Companies per Sector:
What Types of Organizations Make up the Ecosystem?

About 60% of Canadian blockchain firms offer services related to Cryptocurrencies, Finance & Fintech, or Blockchain Consulting. These groups and the use cases associated with them are explored further in Figure 6, preceded by a presentation of this report's complete industry data. Figure 4 shows the results from ICTC's primary research on blockchain companies in Canada. In total, 288 blockchain and Cryptocurrency firms have been sorted into sectors, and the number of companies in 2019 in each sector is shown in the figure. ICTC also collected data on an additional 138 firms that were not included in the pie chart either because the firm's business model was inscrutable, or it had no identifiable Canadian employees.

Figure 4: *Canadian Blockchain Ecosystem, Companies per Sector*

Cryptocurrency 22%
3% Entertainment & Media
3% Energy/Utilities
3% Management Consulting & Law
4% Supply Chain
5% Retail & Consumer
2% Indentity Management
2% Venture Capital & Private Equity
0.7% Real Estate
0.3% Health & Lifescience
5% Education
Finance & Fintech 22%
5% Marketing/Advocacy
Blockchain Consulting 14%
11% ITC & Software
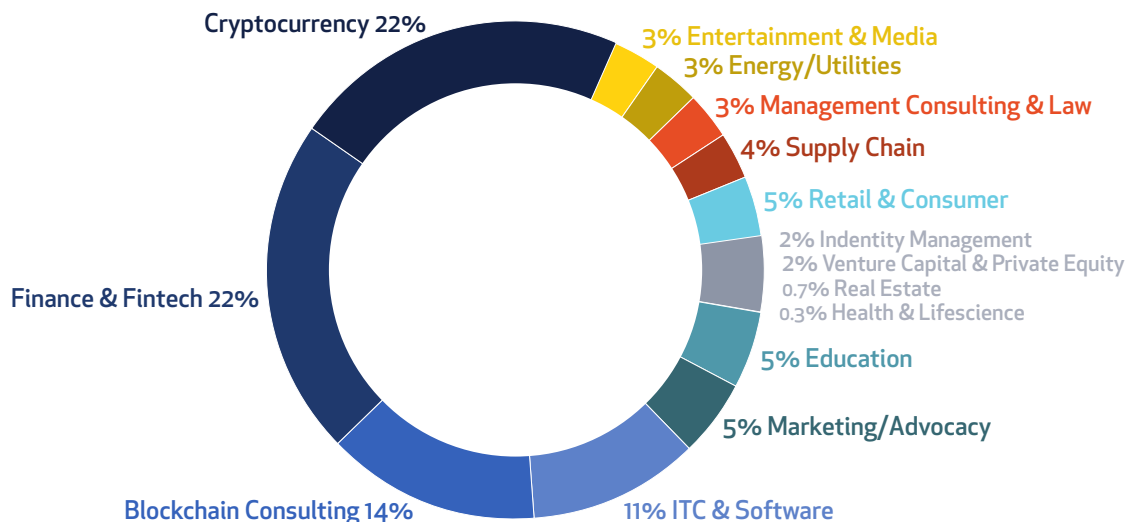
Source: ICTC Note: Unverified companies excluded

[42]*Jasper Phases I, II, and III were partnerships between Payments Canada, TMX Group, the Bank of Canada, Accenture, and R3. They sought to evaluate DLT and its potential for financial infrastructure in Canada. Jasper III found that several aspects of DLT show promise, including integration of different financial market infrastructure, concluding that an expansion of the proof-of-concept to include further assets and components of trade would be required to verify DLT's potential to improve transaction efficiency. See Jasper Phase III: Securities Settlement Using Distributed Ledger Technology, October 2018, https://www.payments.ca/sites/default/files/jasper_phase_iii_whitepaper_final_0.pdf*

Figure 5 also shows the breakdown of blockchain industry, but across time. This figure reveals the timing of the explosion in commercial activity in the Canadian blockchain ecosystem. The highest growth rate in the number of firms that were identified by ICTC's search occurred from 2016-2017. In terms of sector growth rates, cryptocurrency firms were found to be growing fastest from 2015 forward, but the difference in growth rates between sectors is not large—different components of the blockchain ecosystem are apparently growing at similar rates. We also observe that a few sectors appear in more recent years—for example, healthcare and real estate blockchain applications both have appeared in Canada only since 2017, and only a handful of blockchain companies focus in these areas.

A clear visual trend indicates a tapering in growth since the end of 2017 (the start of what is commonly known as "cryptowinter," following the drop in Bitcoin's price and the beginning of the Quadriga exchange lawsuit in Canada). The value for 2019 is based on only the first half of the year, so it is an underestimate. Nevertheless, there appears to be a slowdown in the growth of new blockchain firms since 2016-2017, when the number of blockchain firms roughly doubled. From 2017 to 2018, the number of blockchain firms in Canada grew by about 30%, while if growth trends for the first half of 2019 continue, the number of new blockchain firms will have grown by 25% in 2019. Thus, growth in blockchain businesses is still rather robust, but much less rapid than its peak prior to cryptowinter.

Figure 5: *Blockchain Sectors Across Time*
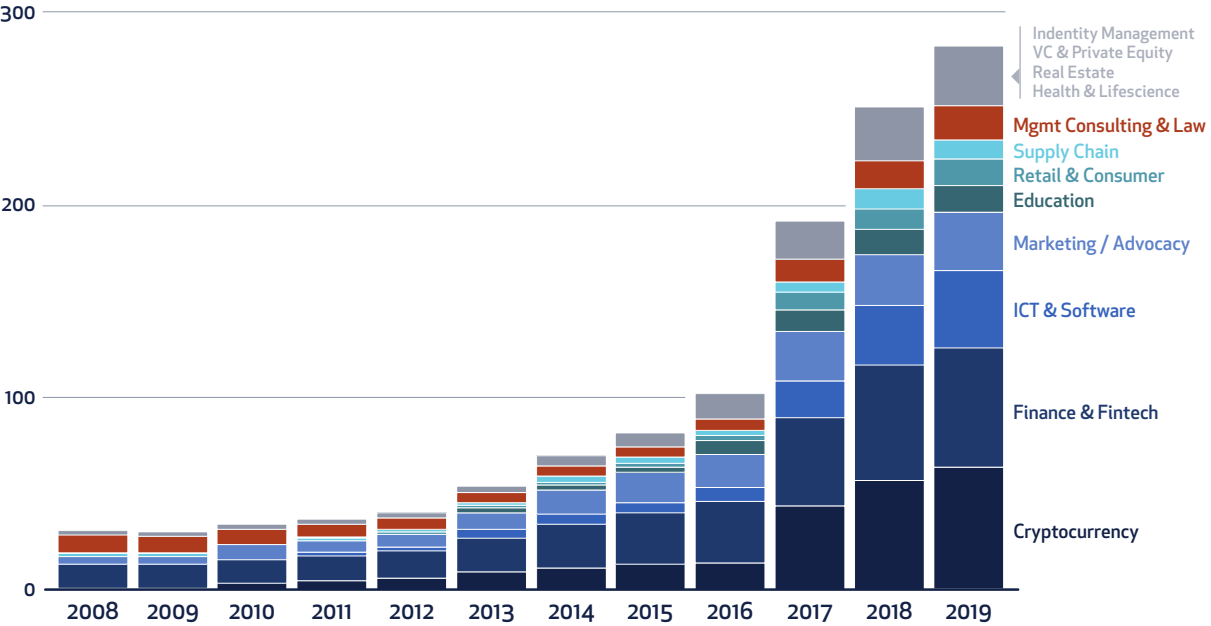
Source: ICTC Note: 2019 value based on first half of year

Blockchain Use Cases and their Relationship to Industry

In Canada, many applications of blockchain, and particularly those outside of financial applications, are still in proof-of-concept phase.

This is in line with global estimates stating that only 15% of organizations would characterize their blockchain applications as "live."[43] Accordingly, nearly one-fifth (18%)[44] of the organizations devoted to blockchain in Canada can be thought of as "blockchain consulting," that is, organizations that partner with existing businesses to help them build a custom blockchain solution, proof-of-concept (PoC), or prepare for the changes that blockchain may bring to their industry.

Several interviewees suggested that blockchain technology's emergent nature means that it is so far difficult to tell which PoCs will meet with success, and which will prove to be more easily implemented by a simpler technology. In part, this is due to the relative youth of blockchain platforms: some industry consultants noted that Ethereum is still ironing out issues, and enterprise solutions like Hyperledger are still working on standardization and client support. Therefore, a proliferation of blockchain solutions that are untested by time does not make it easy for a new company to choose a platform they are confident will stay relevant and usable over many years.

In a market characterized by exploratory research and development, blockchain is currently better-represented in the industries or sectors where it presents a more appropriate and mature use case.

Finance and fintech-related use cases are widely perceived as the most mature for blockchain in Canada, with emerging applications in the supply chain, identity, and other fields are picking up steam. Figure 6 presents the wide array of use cases relevant to blockchain in Canada, along with a use-case-oriented breakdown of the companies that ICTC identified as blockchain-related.

Figure 6: Blockchain Use Case Snapshots in Canada

Financial Services & Fintech

Blockchain's properties enable traceable and simultaneously reconcilable record-keeping between different parties without requiring mutual trust, facilitating applications like cross-border and inter-currency payments.

In addition to finance and fintech, cryptocurrency applications can include digital solutions (such as wallets, software, or tokens), services (such as exchanges or investment guidance), and hardware or mining services, among numerous other use cases for digital assets.

Finance-related Blockchain Companies*

- 1.4% Venture capital / private equity
- 3.9% Other cryptocurrency
- 4.2% Cryptocurrency (mining / hardware)
- 4.6% Cryptocurrency (wallet, software, token)
- 9.8% Cryptocurrency (exchange or investment)
- 22.1% Finance & Fintech
- 54.0% Non-Finance Use Cases

[43]*PwC Global, PwC Global Blockchain survey, 2018. https://www.pwc.com/gx/en/issues/blockchain/blockchain-in-business.html*
[44]*Based on a sample of blockchain companies with Canadian employees that excludes companies primarily devoted to cryptocurrencies.*

Information & Communications Technology (ICT)

As a distributed ledger, many of blockchain's most fundamental use cases are related to ICT services. Companies may make blockchain software or hardware, or offer blockchain consulting to help other organizations develop their own solutions.

ICT-related Blockchain Companies*

Percentage	Category
2.1%	Identity & Credential
3.5%	IT for Retail & Consumers
10.5%	Software and ICT Services
14.4%	Blockchain Consulting+
46.0%	Finance-related
23.5%	Other use cases
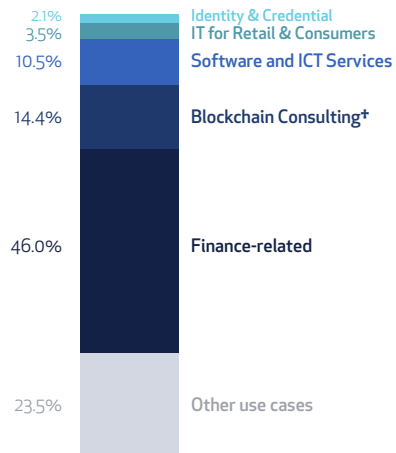
Cultural Industries & Education

Blockchain is both behind the scenes in the cultural industries, tracking IP and facilitating content creation, and having its moment on the cultural stage: Blockchain advocates & educators are filling demand for blockchain developers and business-savvy experts.

Culture and Education-related Blockchain Companies*

Percentage	Category
3.2%	Entertainment & Media
4.6%	Education
5.3%	Marketing & advocacy
30.5%	ICT-related
46.0%	Finance-related
10.5%	Other use cases

BLOCKCHAIN USE CASES

Applications of blockchain around the world & in Canada

Financial Services and Fintech
- DeFi
- P2P transactions
- Crossborder payments
- Digital asset management
- Insurance
- Crowdfunding
- Customer loyalty & retail
- Credential management

ICT Services
- Blockchain consulting
- Data management software
- Decentralize storage
- Blockchain education: business & dev

Cultural Industries and Education
- Micropayments for content consumption
- P2P ticketing
- Gaming
- Blockchain marketing & advocacy
- IP for composite products

Governance
- Auditing & recordkeeping
- Digital identity verification
- Electronic medical records
- Privacy & data governance
- E-government services

Energy, environment, and utilities
- Environmental & resource management
- Microgrids & P2P energy transactions
- Carbon credit & emissions management

Advanced Manufacturing and Supply Chain Management
- Provenance tracking (SCM & environmental)
- IoT integration
- International trade
- P2P manufacturing

In Canada's blockchain ecosystem, when sectors are clustered into larger thematic groups, financial services; ICT services; and cultural industries, digital media, and education are in the lead.

Financial services and fintech are often cited as being home to the most common blockchain use cases, and this sector has had a head start in developing blockchain applications, but the industry ecosystem has begun to look more diverse as other sectors begin developing PoCs.[45]

[45]Gartner reports that financial services dropped from 82% to 46% of reported blockchain use cases worldwide between 2017 and 2018. See "Blockchain potential and pitfalls," Gartner, https://www.gartner.com/en/webinars/3878710/blockchain-potential-and-pitfalls

Several interviewees in different blockchain fields described the reasons why they chose to situate their business in a particular use case: whether mature or up-and-coming, blockchain is exciting to many entrepreneurs and established businesses as an opportunity to create entirely novel applications.

INTELLECTUAL PROPERTY TRACKING IN CULTURAL MEDIA
Manuel Badel, Badel Media

"A use case that is important to me is IP, rights management, and rights monetization for creators, producers, and all the different stakeholders involved in content production, financing, and distribution. How they can be fairly protected, and benefit from blockchain, through tracking solutions that cope with today's multiplication of digital platforms, where people can create, modify, and share content through social networks and a diversity of applications. It's so easy to access content in a digital format that we lose its traceability, original creators are more and more lost and not always remunerated in an appropriate and efficient way."

DIGITAL CONTRACT MANAGEMENT FOR ECOMMERCE
David Sopuch, Avetti Commerce

"The whole point of blockchain is an immutable record. If you have a buyer and a seller negotiating a price, in a B2B transaction, they can go back and forth in negotiations: one of the problems that occurs is that if the two disagree on what the final agreement was, they could both say, "here's a screenshot of my page," basically. So how do you prove that the contract has or hasn't changed, especially in a day and age where hackers could have changed something? Blockchain becomes very important in marketplaces and B2B e-commerce."

SUPPLY-CHAIN MANAGEMENT
Erik Valiquette, Canadian Blockchain Supply Chain Association (CBSA)

"In the lettuce example, which I like to use to illustrate a supply chain blockchain, the supply chain begins with the guy selling the seed to the farmer. The farmer plants the seed, there's a pesticide guy, and there might be IoT sensors for temperature and humidity records. Then someone takes it out of the ground, there's a carrier bringing it to the local buyer or distributor, the warehouse, pickup, delivery, customs, and transportation. So you can record location, routes, delivery time, temperature, humidity— different touch points all the way to the consumer, with humans and sensors inputting the data. Today, a lot of this is still done on paper, so it's important to bring in a trusted and shareable source of digital information and get rid of cumbersome physical paperwork."

DECENTRALIZED FINANCE
Alim Khamisa, Alkemi

"Sitting at the intersection of financial products and decentralized networks, DeFi [decentralized finance] is about unbundling the financial stack into a permissionless system, open to anyone around the world. The ultimate goal is to disintermediate the middlemen and abstract away the 'trust' layer from centralized institutions, allowing for better access to financial products and services, and more fluid movement of value."

In a further illustration of differences in maturity by use case and/or industry, blockchain-related companies differ in average size by type of firm. Figure 7 shows the average number of blockchain-related workers at blockchain-focused companies (or business units of large firms) by industry. Business units are used for large established firms as this better reflects the "size" of blockchain activity in large firms, such as legacy consulting and law firms, rather than including the full company size which is often in the tens of thousands. More established industries, such as Software and Fintech, tend to have larger numbers of employees, while emerging application areas, like Real Estate and Life sciences, remain small. Organizations categorized in management consulting and law are often large, pre-existing enterprises.

Figure 7: *Average Number of Blockchain Workers per Company or Blockchain Business Unit by Industry, Canada, 2019*

Industry	Average
Mgmt Consulting & Law	14.6
ICT & Software	11.4
Finance & Fintech	7.9
Retail & Consumer	6.1
Entertainment & Media	6.0
Education	5.4
Blockchain Consulting	5.3
Identity Management	4.5
Marketing/Advocacy	4.5
Energy/Utilities	4.0
Supply Chain	3.9
Cryptocurrency	3.4
Health & Lifesciences	2.0
VC & PE	1.8
Real Estate	1.3

Source: ICTC Note: In large firms, "size" refers to the blockchain business unit

## Blockchain Across Canada: Regional Ecosystems

Many industry consultants date the beginning of blockchain as we know it today to the creation not of Bitcoin, but of Ethereum, called by one interviewee "the second generation of blockchain," and founded in Canada. Ethereum was the first Turing-complete blockchain protocol, allowing developers to use it to build smart contracts and decentralized apps. Interviewees noted that Ethereum was first proposed in 2013, emerging from a meetup community in Toronto that included founders Vitalik Buterin, Mihai Alisie, and Anthony Di Iorio, the former two of whom later moved to Switzerland for regulatory reasons.

While blockchain is now an international phenomenon, Canada remains home to one of its key founding communities, and the network of developers and start-ups tied to Toronto remains strong. Beyond Ontario, however, regions across the country are beginning to develop their own blockchain and cryptocurrency reputations. The five provinces with the most blockchain company headquarters in Canada are showcased in Figure 8, along with supplementary data on blockchain platforms of interest to the public (via Meetup), employee migration, and qualitative associations with each province.

Canada's Blockchain Hubs

Fast facts about our regional centers of expertise.

Figure 8: *Canada's Blockchain Hubs*
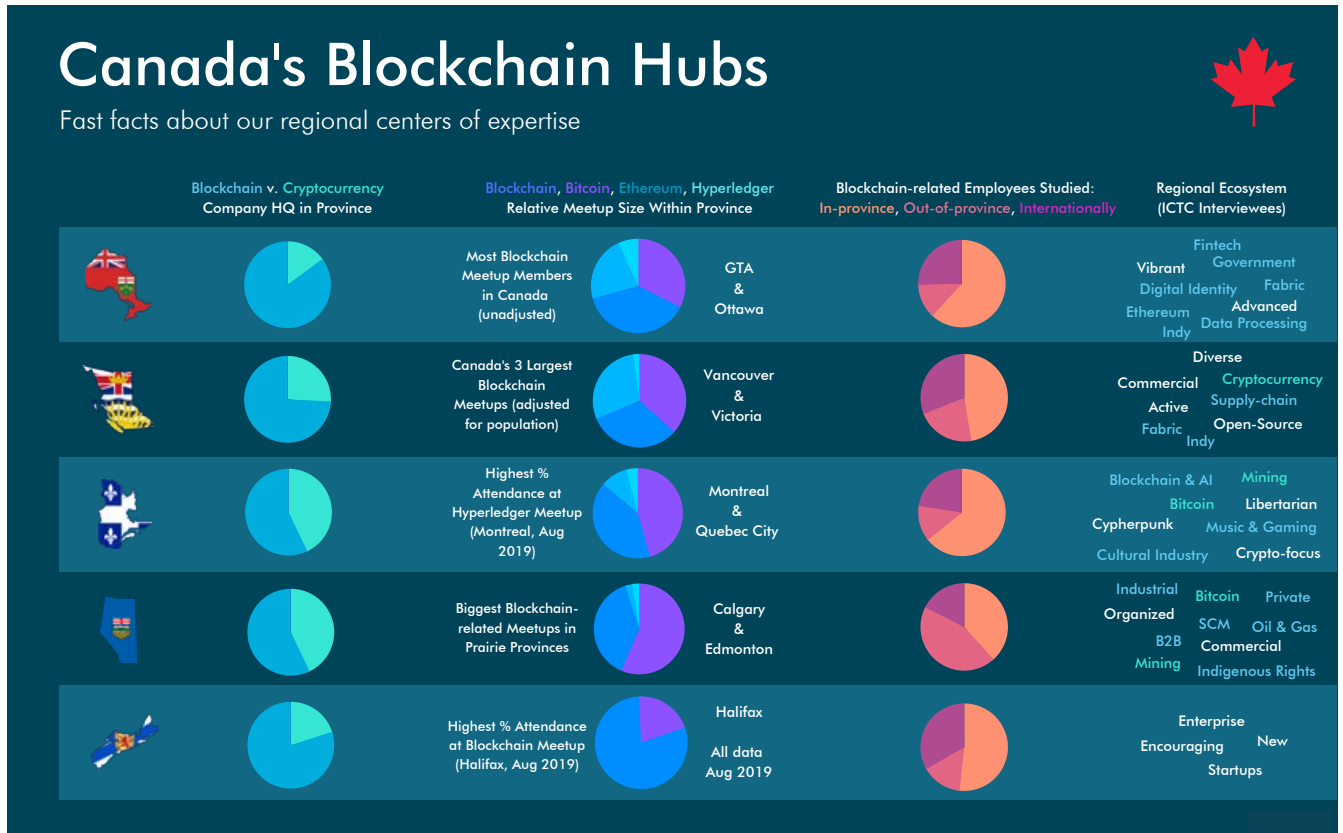
Source: ICTC

Why meetup?

In Figure 8, Meetup data is used to illustrate the diversity of blockchain-related communities in different regions of Canada, as well as the strength of interest in blockchain vs. cryptocurrencies. During ICTC's consultations with members of the blockchain and cryptocurrency industries, several independently raised the fact that Meetups, the online service for organizing in-person events around shared interests, had comprised a vibrant component of blockchain's growth in Canada, particularly in the early years of the technology before knowledge of it was widespread.

> I think the core of blockchain is the meetup system, where developers, investors, service providers or people who are simply curious can go and learn about blockchain and keep up with this fast-moving industry—particularly in Toronto, Ottawa, Montreal, Waterloo.

- Laura Gheorghiu, Gowling WLG Canada

> I have gotten to know most of the blockchain industry in Toronto through a combination of meetups and conferences.

- Andreas Veneris, University of Toronto

> In 2016, I read Blockchain Revolution by Don and Alex Tapscott for a Globe and Mail column I was working on, and I quickly became fully immersed. Up until that time, you had to go to Meetups to find out anything.

- Hilary Carter, Managing Director of the Blockchain Research Institute

Early meetups were particularly vibrant in Ontario and Quebec, but recent years have seen the emergence of similar informal organizations in British Columbia, which now boasts the largest blockchain meetup (adjusted for population), as well as in the Prairie Provinces and the Maritimes. At the time of data collection, there were no blockchain-related meetups in the territorial capitals of Iqaluit, Yellowknife, and Whitehorse.

The Blockchain Industry: Provincial Hubs of Activity

Beyond being the home of Ethereum, Toronto (and Ontario more generally) was characterized by many industry consultants as a centre for fintech experimentation, and government involvement with blockchain (working with applications such as digital identity and data processing), with a balance between the decentralized ecosystem of Ethereum and the enterprise ecosystem of platforms like Hyperledger.

British Columbia is an up and coming player in Canada's blockchain space: rapidly overtaking Toronto in interest and number of companies when population differences are considered, BC is seen as a hub for diverse projects, not limited to a particular industry or platform.

The province of Quebec has a history of first encouraging and then disincentivizing investment in cryptocurrencies and related technologies: several interviewees commented that the history of encouraging, banning, and then re-introducing the sale of electricity to cryptominers has made some cryptocurrency-related companies mistrust long-term stability in the province. However, others commented that Quebec is Canada's stronghold of some of the blockchain and Bitcoin community's cypherpunk roots, and that it will be a source of decentralized innovation in the future.
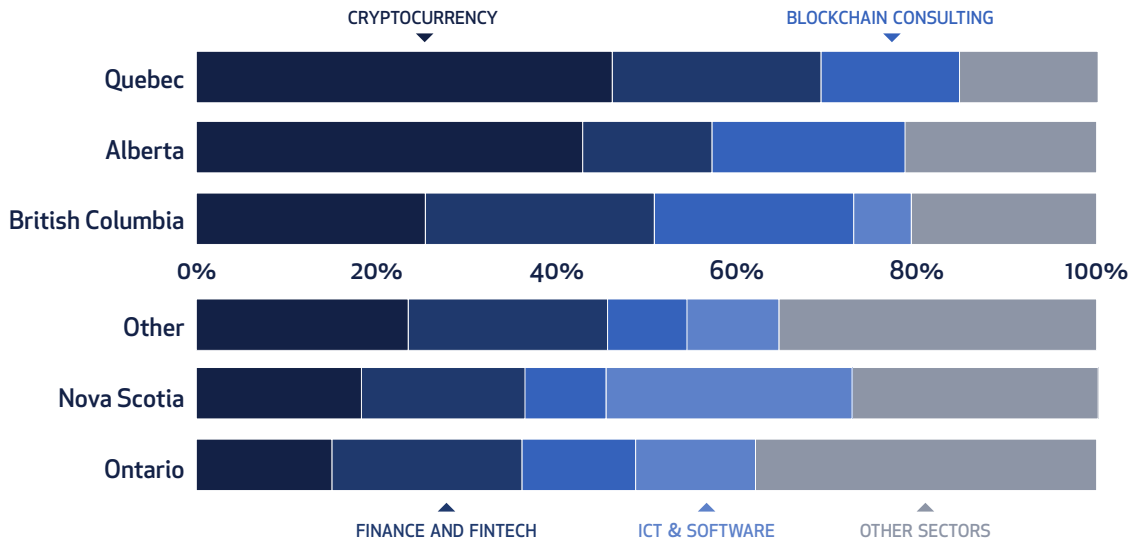
Alberta is well-known for its oil and gas industry, and interviewees also classified many of the province's blockchain use cases as extractives-related. Broadly speaking, however, the province is well-regarded as having a well-organized, unified blockchain community that is interested in supply-chain management and provenance tracing as well as cryptocurrencies.

While not all industry consultants had a lot to say about Nova Scotia's blockchain ecosystem, the province competes with Alberta in many of ICTC's indicators of blockchain innovation, and a strong start-up ecosystem in Halifax has begun to take a clear place on the Canadian stage. A number of big players in fintech and peer-to-peer gambling are headquartered in the province.

Blockchain by the numbers: A provincial overview

As seen previously, blockchain companies in Canada are primarily concentrated in cryptocurrency-related services, finance and fintech, and blockchain consulting, followed by ICT and software services (where a pre-developed blockchain solution is offered across industries, rather than "blockchain consulting" where the product is custom-made). However, the top services offered across Canada vary slightly when examined in different provinces. Figure 9 showcases the distribution of blockchain firms across sectors in Canadian provinces, as measured by the number of blockchain companies headquartered in that province (not taking into account company size, nor including companies headquartered elsewhere with units in the province). As a proportion of the total, a larger volume of cryptocurrency firms is found in Quebec and Alberta, while Ontario has a highly diversified blockchain ecosystem, and British Columbia possesses a substantial footprint for Finance/Fintech and Blockchain Consulting firms. One important consideration to note is that cryptocurrency firms tend to represent a larger proportion of blockchain firms in markets that are newly emerging or in the process of maturing. As a result, in more mature markets like Ontario and BC, an increasing presence of alternative blockchain use-cases appears.
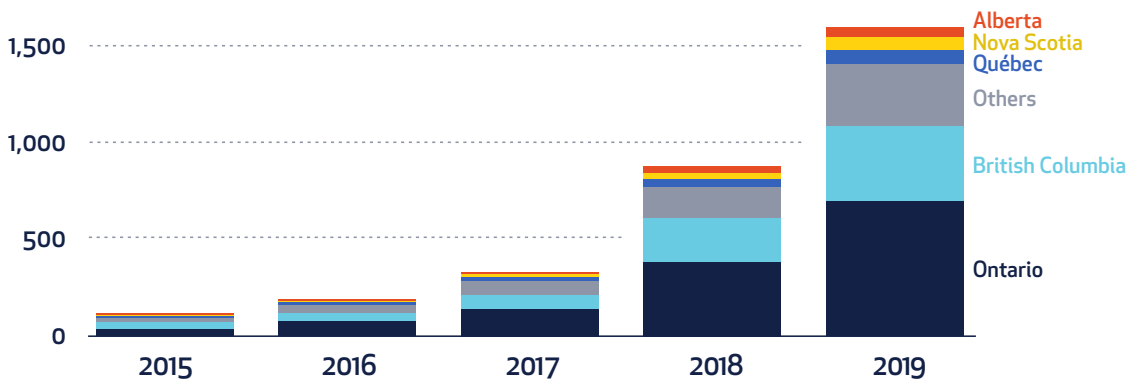
Figure 9: *The Proportion of Types of Blockchain Companies Headquartered in Each Province*

CRYPTOCURRENCY · BLOCKCHAIN CONSULTING

Quebec · Alberta · British Columbia · Other · Nova Scotia · Ontario

0% · 20% · 40% · 60% · 80% · 100%

FINANCE AND FINTECH · ICT & SOFTWARE · OTHER SECTORS

Source: ICTC Note: Based on number of headquarters based in province, several provinces & territories excluded due to low sample size, sample size differs by province

Naturally tied to blockchain business growth is growth in the labour force and increasing existence of blockchain-skilled workers. Figure 10 highlights this growth in blockchain workers across Canadian provinces across time. While Ontario and British Columbia currently absorb the majority of blockchain workers, smaller provinces are also scaling quickly when it comes to their ability to attract and develop this skilled talent base. In fact, Alberta tripled its volume of blockchain workers from 2018 through the first half of 2019, and Nova Scotia grew from zero in 2016 to over fifty by the first half of 2019. Comparatively, despite their overall share of total blockchain talent, Ontario and British Columbia, the markets currently absorbing nearly 70% of blockchain workers in Canada, grew more modestly over the same time period.

**Figure 10:** *Blockchain Workers by Province in Canada, 2019 data*

Alberta · Nova Scotia · Québec · Others · British Columbia · Ontario

1,500 · 1,000 · 500 · 0

2015 · 2016 · 2017 · 2018 · 2019

Source: ICTC Note: 2019 value based on first half of year

Analyzing job postings in recent years can also provide an idea of where growth is taking place. Figure 11 shows the total number of blockchain-related job postings from November 2017 to August 2019, as scraped from jobs boards. Aligned with the evidence presented above, most postings (two thirds) were for positions in Toronto and Vancouver. These two cities are quite simply the core of blockchain activity in Canada.

Figure 11: Number of Unique Blockchain Job Posts by Canadian Cities
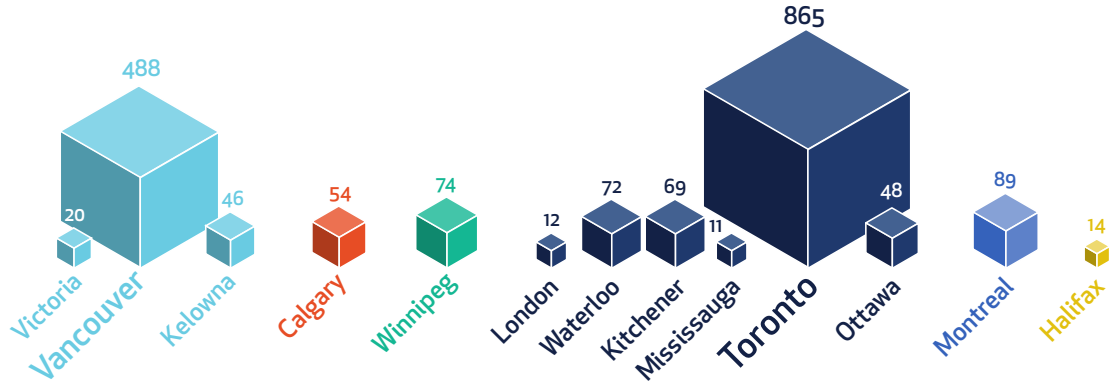
Source: ICTC, Emsi Note: Search keyword logic is (hyperledger OR ethereum OR corda OR solidity OR ASIC OR bitcoin OR hashrate OR DApp OR ICO OR litecoin OR ledger) AND (blockchain OR cryptocurrency OR distributed ledger)

Despite the disproportionate weight of British Columbia and Ontario, regional ecosystems in Canada tend to be highly interlinked, and blockchain workers are unusually mobile within Canada and internationally. Analysis of the last location of study for blockchain workers completed by ICTC reinforces this mobility. Figure 12 shows the province or country of the last place of study for current blockchain workers. In total, about one quarter of blockchain workers in Canada studied outside of Canada, according to this assessment.

Figure 12: Last Location of Post-secondary Study for Canadian Blockchain Workers (2019)
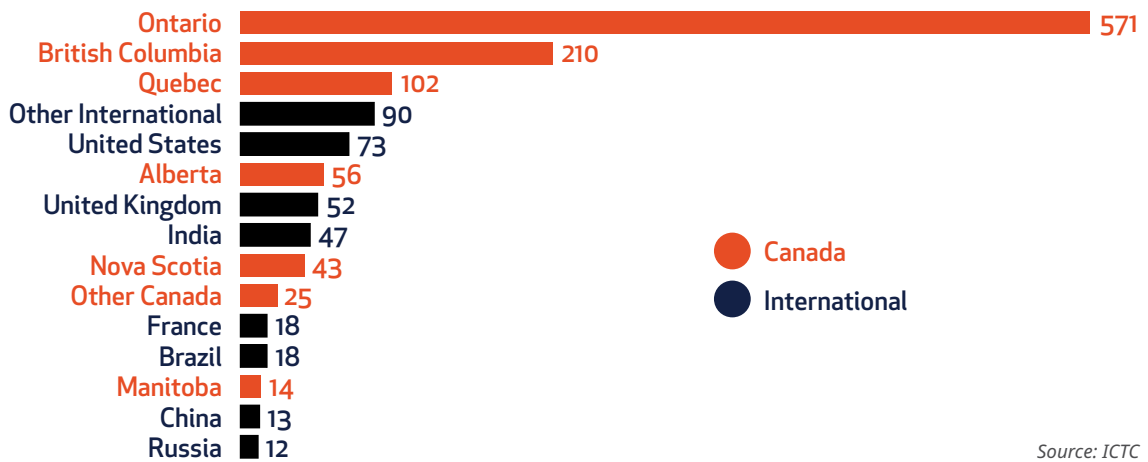
Source: ICTC

Further to the topic of worker mobility, blockchain workers appear to also be highly likely to move between provinces. A provincial snapshot showcases that a significant portion (sometimes more than half) of blockchain workers within a certain province actually acquired their education outside of the province, or outside of the country altogether. Quebec has the highest proportion of blockchain workers who studied in the same province, but about a third of the workforce still studied outside of the province. These figures point to a highly international and mobile workforce and suggest that these typically highly skilled workers could leave Canada if it becomes unattractive for blockchain firms.

Figure 13: *Canadian Intranational Blockchain Worker Migration*

Location of Education
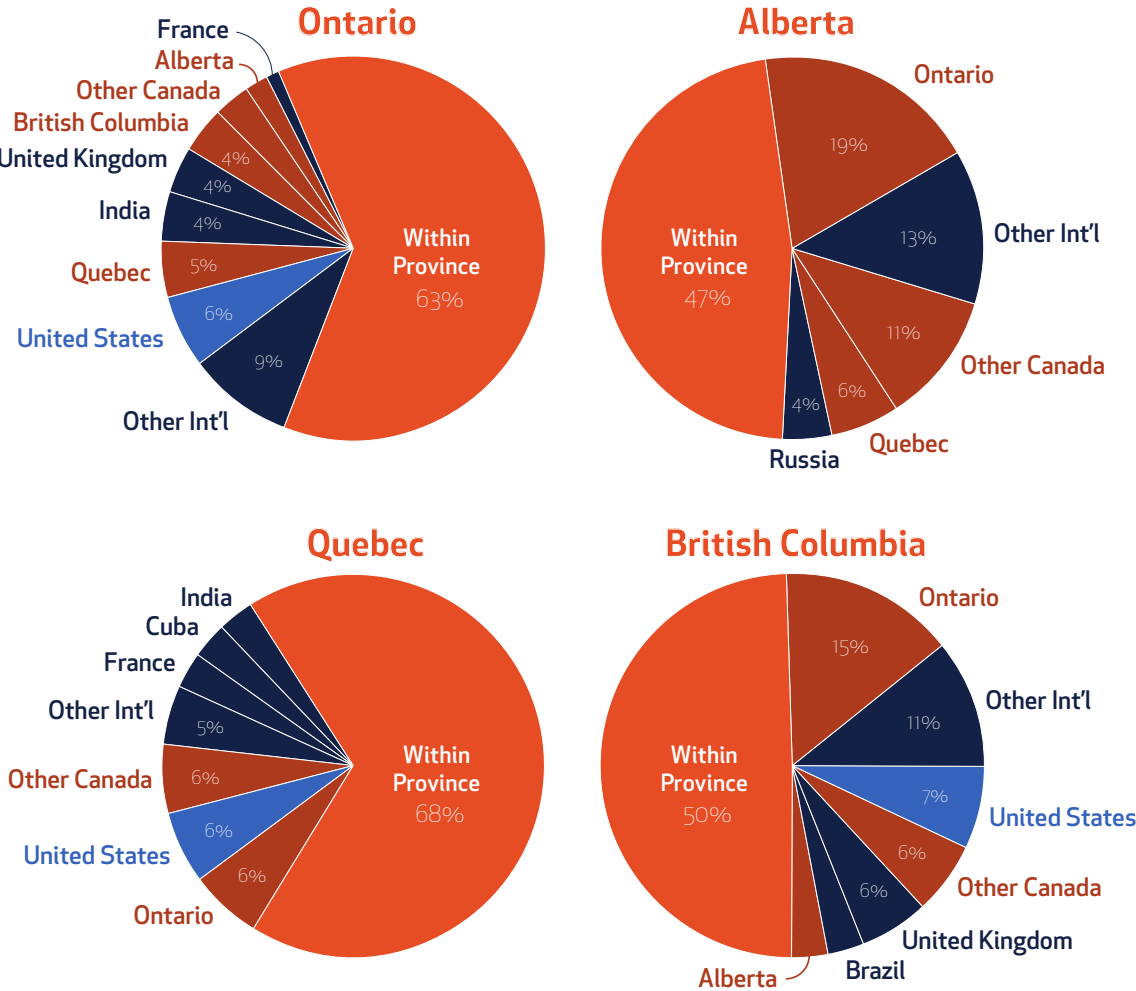
Source: ICTC

Studying Blockchain in Canada: Emerging Trends in Education

Training Options in Canada

While most companies hiring blockchain professionals concur that their employees have either taught themselves about blockchain or learned on the job, a small cohort of Canadian educational institutions are beginning to respond to demand for blockchain talent with interdisciplinary programming for blockchain developers and marketing professionals. Internationally, this trend was led by the University of Nicosia in Cyprus, which launched the first blockchain MOOC over five years ago and also became the first University to take Bitcoin as tuition payment in 2014. Five of ICTC's interviewees worked for organizations primarily dedicated to post-secondary education, and an additional seven offered some kind of educational consulting service to clients or the public.

Developer training:

Blockchain knowledge is dynamic and quickly changing, and embedding approved curriculum into a post-secondary institution—not to mention holding on to the instructors qualified to teach it—has proved challenging for organizations across Canada. Nevertheless, a few institutions like York University, George Brown College, and UBC, along with organizations like CryptoChicks and Creative Destruction Labs have begun to offer formal programs for blockchain development (see Figure 14). In addition to the courses illustrated in Figure 14, several new programs are in development, such as a York University School of Continuing Studies certificate program in back-end and blockchain development.

Studying Blockchain Development in Canada: Post-Secondary Program Snapshots

First Cohort 2017

Short-term Certificates
Ethereum
Hyperledger
Full-Stack
Business Applications

"Our mandate is to build an innovation hub around blockchain, one that is sustainable. In this space we try to offer practical products, mentorship and relationships, and hands-on work rather than just online courses."
- Omid Sadeghi, Executive Director of The BlockchainHub at York University

First Cohort 2018
7 Developer Alumni

Three-semester Program
Full-Stack, Architecture
Smart Contracts, DApp Design
Laws and Regulations
Work-Integrated Learning

"We are the first post-secondary institution in Canada to offer a development-specific blockchain certificate. People who have never written a line of code before can take it, and many of our students have job offers coming out of their co-op placements."
- Ceit Butler, Professor & Program Coordinator of Blockchain Development, George Brown College

First Cohort 2020
Alumni Target: 139 in 6 y

Graduate Specialization
Twelve credit minimum
Industry internship
Focus on health, reg tech, clean energy, Indigenous apps

"We see a need to build multidisciplinary perspectives - a need for people who can look at a problem space, a social or business goal, and then come up with a solution using blockchain tech. We're training students to understand all layers - social/business, data/records and technical - of solution design."
- Victoria Lemieux, Associate Professor, Founder & Co-Lead, Blockchain @UBC

Other paths for Canadian blockchain developers in-training

Incubators & accelerators

In-person meetings & hackathons

Open-source resources for learning and collaboration

Bootcamps and micro-credentials
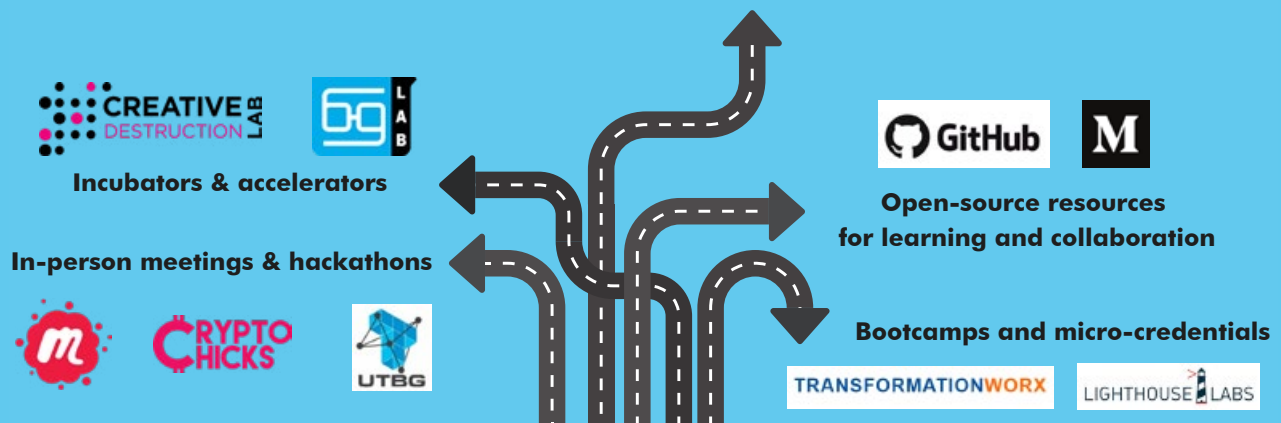
Education for business:

While the space of micro-credentialing tied to blockchain is wide and varying, numerous Canadians—both at the individual and organizational levels—are in on the ground floor. The organization TransformationWorx, founded in 2017 and based in Ontario, for example, offers two-day bootcamp-style courses in blockchain and solution design for professionals:

> We provide rapid skills development for professionals and organizations in areas of disruptive technologies and solution design. We liken the program to an applied "nano-MBA," where value from use of emerging technologies and disruptive business models is identified and extracted using practical methodologies and proven tools suited to business environments.
>
> - Dawood Khan, TransformationWorx

Legal and information governance training:

Several Canadian institutions, including the University of Ottawa and UBC, have launched law and policy-oriented modules or research groups on blockchain. Their purviews include analyses of the legal implications of blockchains, cryptocurrencies, and smart contracts, and extend to identity and privacy management, legal tech, and archival sciences perspectives on blockchain, and their students are mostly working at the graduate research level.[47]
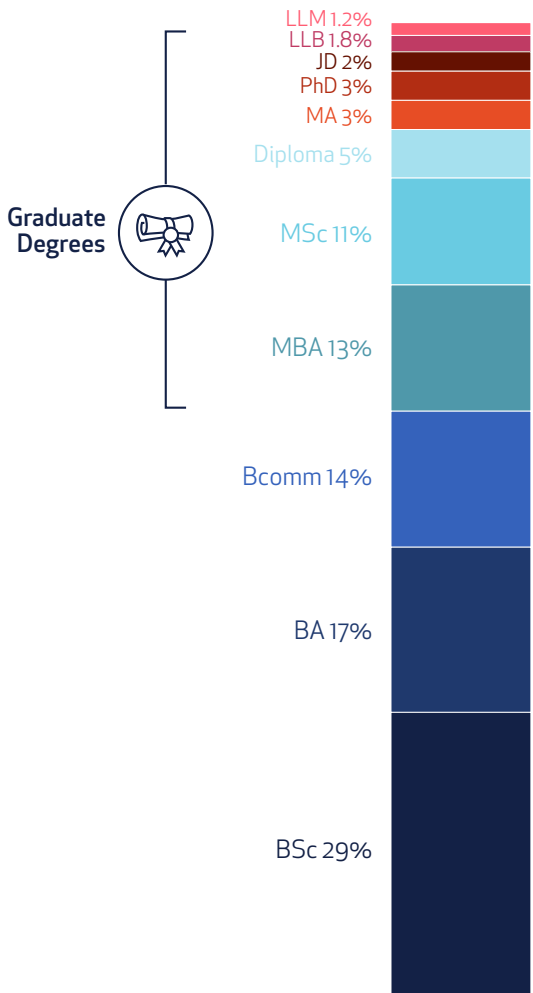
Current Education of Blockchain Professionals

Regardless of the pathways that future blockchain professionals will take, today's blockchain workers are highly educated and oriented towards STEM fields.

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[47]For more information about the University of Ottawa's program, consult http://blckchn.ca/#about; for UBC, see https://blockchain.ubc.ca/about-us

Figure 15 shows the types of degrees held by blockchain workers in Canada. Advanced degrees have been "popped out" of the pie chart, indicating that over a quarter of post-secondary-educated blockchain workers have a graduate degree. The most common final degree type is a Bachelor of Science or Applied Science.

Similarly, Figure 16 highlights the specific field of study of blockchain workers, once again showcasing a considerable tilt towards STEM education. The Computer Sciences and Applied Engineering fields account for over one-third of those with post-secondary education. Those who studied Management, Accounting, or Finance account for nearly another one-quarter of workers.

Figure 15: *Blockchain Workforce Educational Credentials (Most Recent Degree, Canada, 2019)*

Graduate Degrees

LLM 1.2%
LLB 1.8%
JD 2%
PhD 3%
MA 3%
Diploma 5%
MSc 11%
MBA 13%
Bcomm 14%
BA 17%
BSc 29%

Figure 16: *The Canadian Blockchain Workforce's Field of Study (Highest Level of Education, 2019)*

1% Language
1% Science
2% Other
2% Health, Biotech
4% Design
4% Social Science
4% Mathematics
5% Economics
5% IT
6% Political Science, IR, Law
8% Marketing, Media, Comms
10% Accounting, Finance
13% Management
15% Applied Engineering
20% Computer Sciences
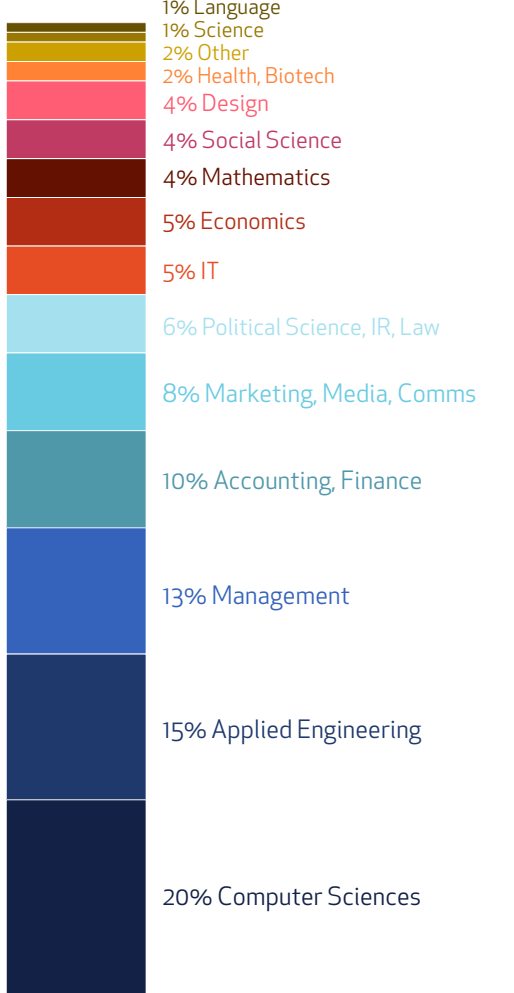
To further explore the educational backgrounds of Canada's blockchain workers, Figure 17 shows the most common alma maters (based on the last institution of study). Underlining the significance of Ontario and British Columbia in drawing workers into blockchain, the top 10 universities or colleges with the most graduates working in blockchain in Canada are located in those two provinces.

Figure 17: *The Canadian Blockchain Workforce's Last University of Study (2019)*

University Of Toronto — 130
University of BC — 73
York University — 72
Western University — 60
University Of Waterloo — 59
Simon Fraser University — 48
Queen's University — 39
Ryerson University — 34
McMaster University — 33
BC Institute of Technology — 32
McGill University — 30
Concordia University — 24
University Of Ottawa — 22
Seneca College — 21
Dalhousie University — 19
University Of Calgary — 18
University Of Victoria — 17
Wilfrid Laurier University — 16
University Of Guelph — 14
University Of Windsor — 12
University Of Alberta — 12
University Of Manitoba — 11
Humber College — 11
Carleton University — 11
Universite De Montreal — 8
Saint Mary's University — 7
University of Newfoundland — 7
Brock University — 6
University Of Lethbridge — 5
Sheridan College — 5
University Of London — 5
Université Laval — 5
Concordia — 5

Ontario
British Columbia
Alberta
Québec
Rest of Canada

Source: ICTC

Working in Blockchain

> It's not a typical industry where the epicentre of the activity is concentrated on traditional firms. We're seeing new organizational forms that go beyond traditional firms and are community-based. The rise of blockchain tech is changing the nature of the actors, the business actors, engaging in the space—they might be loose collectives of individuals attached to traditional firms that might be doing other full-time jobs and working in blockchain in their spare time to contribute to this innovation landscape. There is also a lot of churn, a lot of coming and going.
>
> – Victoria Lemieux, UBC

The blockchain ecosystem has created numerous jobs and avenues for new employment: a blockchain start-up could have a single full-stack blockchain protocol developer, but that person may be complemented by a traditional front-end developer, a UX professional, a project manager, and a marketing or business development professional with blockchain expertise. That start-up may then hire information governance professionals, security analysts, or other consultants. In the cryptocurrency space, new jobs for people that offer wallets, exchanges, or operate Bitcoin ATMs have also been created: blockchain, tokenized or not, has created a number of entirely novel careers.

In addition to jobs and skillsets, blockchain workplace culture came up in several consultations with members of the industry. Many organizations dedicated to blockchain use remote or partially remote workers, and these employees may be spread across Canada or even around the world. Canadian workers may have colleagues in India, New York, and Russia working side-by-side, and blockchain workplaces are said to demand flexibility and a passion for the subject. This trend is echoed by sources such as ConsenSys's blockchain developer job kit, where blockchain jobs are shown to be tagged as remote-friendly twice as frequently as other jobs.[48]

Today's Blockchain Workforce: A Rapidly Maturing Labour Market

In order to understand the people working in Canada's blockchain ecosystem, ICTC collected information from over 1600 individuals, with over 1000 unique job titles. Over time, the number of people working in blockchain has grown exponentially: Figure 18 indicates that the number of workers in the Blockchain ecosystem nearly doubled every year from 2015 to 2019.

[48]ConsenSys,"Blockchain Developer Job Kit," 2019, p.4

Figure 18: *Canadian Blockchain Jobs, by Category*
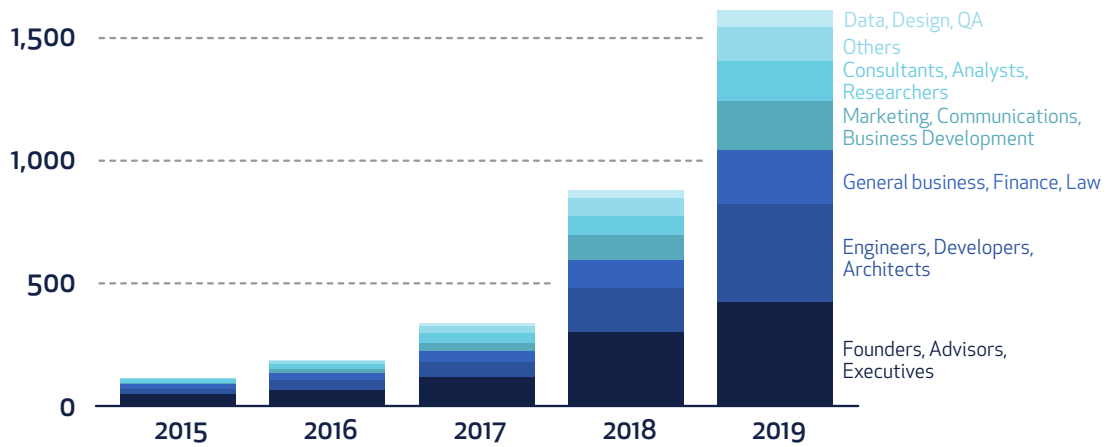
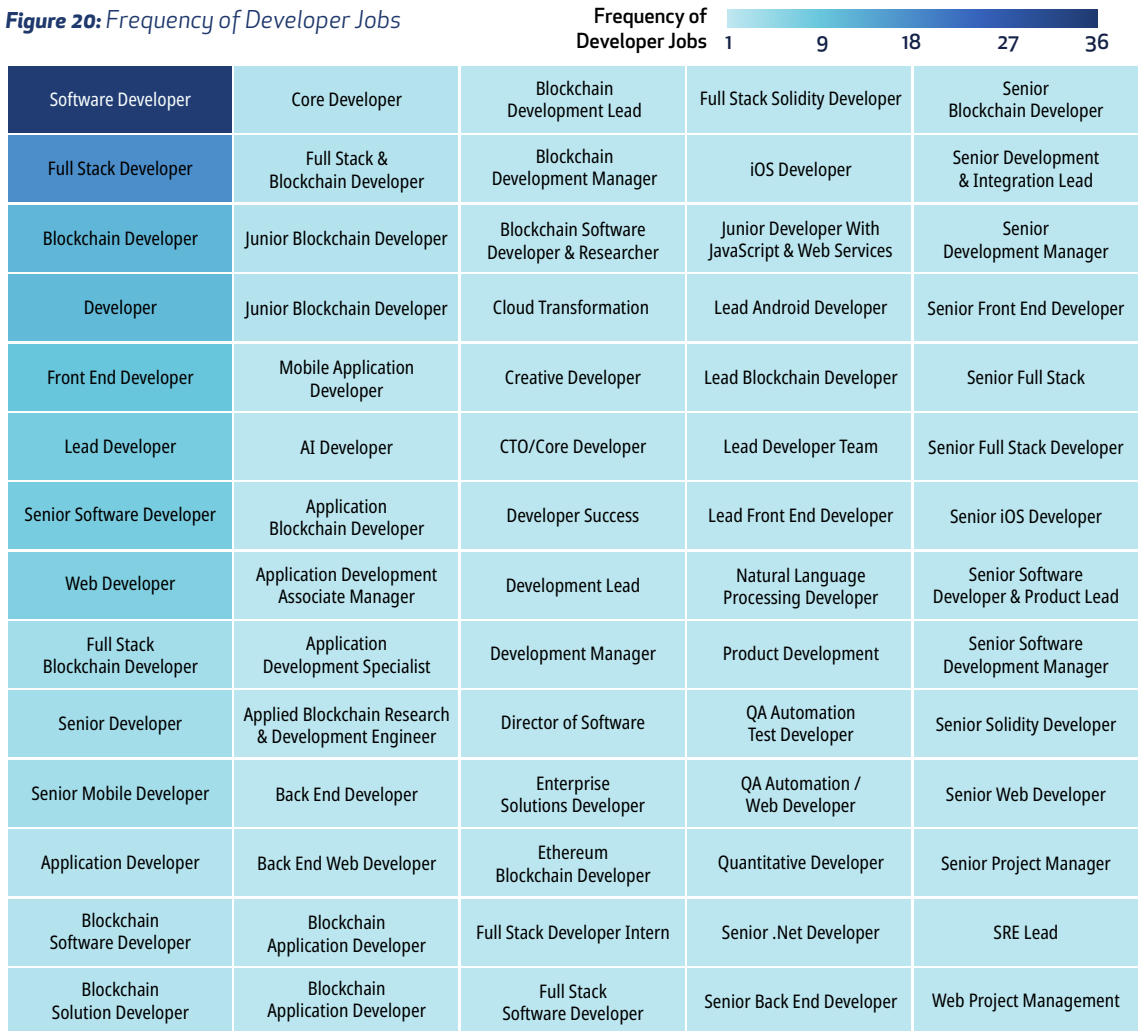Source: ICTC Note: 2019 value based on first half of year

Similarly, the types of jobs held by blockchain workers vary. Figure 18 places job titles of blockchain workers into six main categories, the largest of which is technical jobs: engineers, developers, architects, and product developers. In close second is founders and executives. The most important trend in the workforce over time, aside from the sheer increase in the volume of workers, is the shift from founders towards technical roles, as illustrated most clearly in Figure 19. In almost every year from 2015 to 2019, founders were a declining proportion of blockchain workers, falling from 23% to 14%. Meanwhile, developers grew as a percentage of the total every year, rising from 3% to 11%. This is suggestive of a maturing industry, where entrepreneurs are being supplemented by professionals.
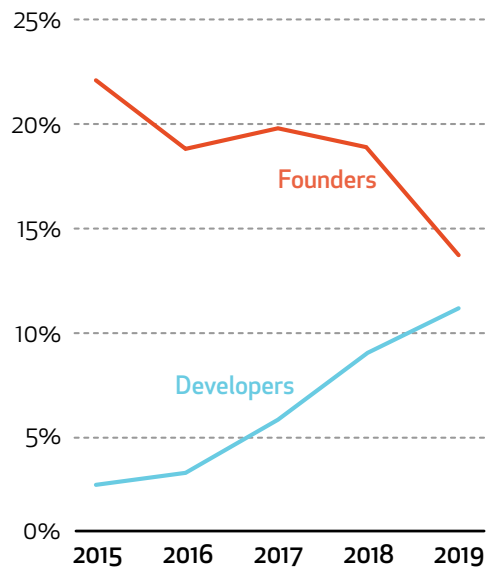
Source: ICTC

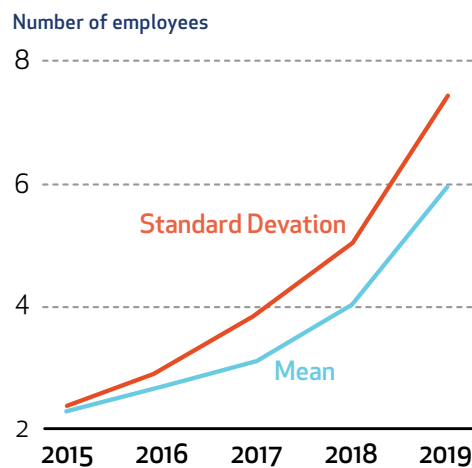Importantly, even within the job category of "developer" many different specific roles exist. Figure 20a presents the unique job titles which have been categorized under "developer" by ICTC across the entire Canadian blockchain ecosystem in 2019. In total, 70 unique job titles exist within the broad category of developer. This is something that demonstrates the diversity of roles within the blockchain ecosystem.

Figure 20: *Frequency of Developer Jobs*

Frequency of Developer Jobs: 1 — 9 — 18 — 27 — 36

Software Developer	Core Developer	Blockchain Development Lead	Full Stack Solidity Developer	Senior Blockchain Developer
Full Stack Developer	Full Stack & Blockchain Developer	Blockchain Development Manager	iOS Developer	Senior Development & Integration Lead
Blockchain Developer	Junior Blockchain Developer	Blockchain Software Developer & Researcher	Junior Developer With JavaScript & Web Services	Senior Development Manager
Developer	Junior Blockchain Developer	Cloud Transformation	Lead Android Developer	Senior Front End Developer
Front End Developer	Mobile Application Developer	Creative Developer	Lead Blockchain Developer	Senior Full Stack
Lead Developer	AI Developer	CTO/Core Developer	Lead Developer Team	Senior Full Stack Developer
Senior Software Developer	Application Blockchain Developer	Developer Success	Lead Front End Developer	Senior iOS Developer
Web Developer	Application Development Associate Manager	Development Lead	Natural Language Processing Developer	Senior Software Developer & Product Lead
Full Stack Blockchain Developer	Application Development Specialist	Development Manager	Product Development	Senior Software Development Manager
Senior Developer	Applied Blockchain Research & Development Engineer	Director of Software	QA Automation Test Developer	Senior Solidity Developer
Senior Mobile Developer	Back End Developer	Enterprise Solutions Developer	QA Automation / Web Developer	Senior Web Developer
Application Developer	Back End Web Developer	Ethereum Blockchain Developer	Quantitative Developer	Senior Project Manager
Blockchain Software Developer	Blockchain Application Developer	Full Stack Developer Intern	Senior .Net Developer	SRE Lead
Blockchain Solution Developer	Blockchain Application Developer	Full Stack Software Developer	Senior Back End Developer	Web Project Management

Source: ICTC

Figure 21: *Blockchain Company Mean Size and Standard Deviation Across Time (Canada)*

Number of employees
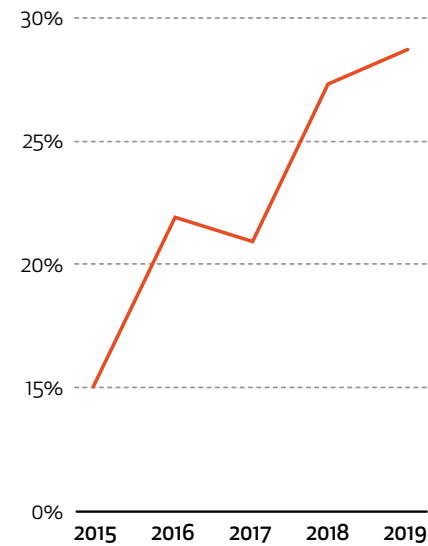
Standard Deviation

Mean

Source: ICTC

The number of employees at blockchain companies, as well as the composition of said employees over time, all point towards a maturing labour market, as illustrated by Figures 21 and 22. Figure 21 shows that the average (mean) size in number of employees for blockchain companies has grown from 2.5 to 6.7 from 2015 to 2019. The standard deviation[49] has also grown considerably, showcasing a pattern of a maturing industry. That is, the average number of employees is rising, but faster for some firms than others.

[49]*In this case, standard deviation measures the variability or variance in the number of employees across companies.*
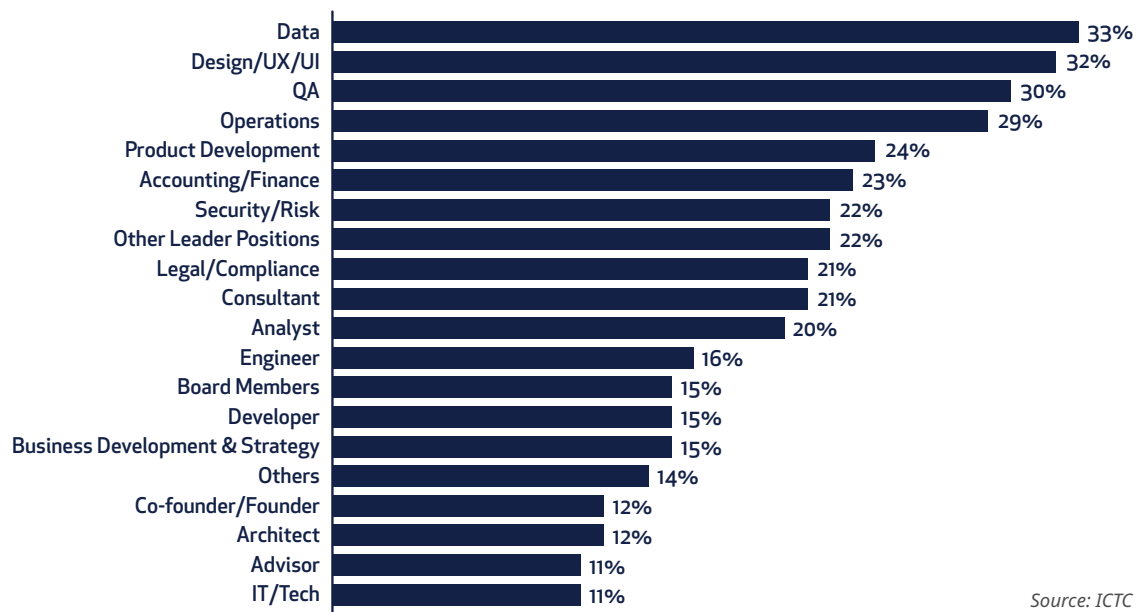
Lastly, a further zoom in on the demographics of blockchain workers reveals an interesting insight when it comes to gender. Figure 22a shows that the portion of blockchain workers that are female rose from 15% to 28% from 2015 to 2019. While 28% is not an indicator of gender equity in the blockchain industry, and in fact is comparable to the rest of the technology sector in Canada,[50] a 13% increase in labour force participation by women in less than 5 years is substantial. To provide additional detail to this trend, Figure 22b shows the percentage of female employees by occupational category. The only job category with greater than 50% female workers is human resources and administration, but anecdotes from consultants reflect a widespread interest in changing this trend: for example, the Alberta Blockchain Consortium's board of directors is very close to modeling gender parity at the time of writing.

Figure 22a: *Percent of Female Blockchain Workers by Year (Canada)*

Source: ICTC

Figure 22b: *Percent of Female Blockchain Workers by Occupation (Canada, 2019)*

Occupation	Percent
Data	33%
Design/UX/UI	32%
QA	30%
Operations	29%
Product Development	24%
Accounting/Finance	23%
Security/Risk	22%
Other Leader Positions	22%
Legal/Compliance	21%
Consultant	21%
Analyst	20%
Engineer	16%
Board Members	15%
Developer	15%
Business Development & Strategy	15%
Others	14%
Co-founder/Founder	12%
Architect	12%
Advisor	11%
IT/Tech	11%

Source: ICTC

[50]*In Q1 2019, ICTC found that women accounted for only 23.5% of the employed ICT workforce in Canada. ICTC, Quarterly Monitor of Canada's ICT Labour Market, Q1 2019, p. 3. https://www.ictc-ctic.ca/wp-content/uploads/2019/07/ICTC_Quarterly-Monitor_2019_Q1_English_Final.pdf*

Blockchain in Demand: Which Personnel are Hardest to Find?

The vast majority of ICTC's industry consultants worked for organizations that had either hired or educated blockchain professionals. These respondents confirmed that there exists great variation in blockchain-related job titles, but the following section clusters relevant skillsets together to look at the in-demand roles unique to the blockchain ecosystem:

(1) technically skilled blockchain professionals and (2) blockchain solutions architects are the top types of in-demand blockchain roles in Canada.

Technically skilled blockchain professionals: Mature Software Developers, Architects, or Engineers with Blockchain Expertise

Overall, many interviewees described difficulties finding back-end or full-stack developers with core blockchain protocol knowledge. While this category of roles is broad—and indeed, the skillsets vary depending on the blockchain solution and platform—interviewees noted that technical pioneers were essential to helping the technology mature and become more accessible to other developers.

Possible job titles for this role, as mentioned by interviewees, included: Blockchain Developer or Architect; Blockchain Protocol Engineer; DApp Developer/Engineer; Ethereum Developer; Enterprise Blockchain Application Developer; Smart Contract Developer or Architect, Software Developer/Engineer; Technical Lead; Full Stack Developer; Back-End Developer; Java, Go, or C++ Developer.

> The high-level skills at the protocol level are really extremely rare. It is 100% self taught. For example, for a Bitcoin developer, compared to most software there is literally 0 room for error. There are no second chances because all your money will be gone, so everything has to be perfect before deployment.
>
> - Dave Bradley, Bull Bitcoin & Alberta Blockchain Consortium

> In 2017/18 there was a flood of companies looking to hire developers who could use Solidity, Ethereum, Hyperledger, or R3 Corda. Now there's a shift in criteria to search instead for mature, professional software engineers and full stack developers, who can produce something that the company can actually use. At the same time, companies are looking to internal software engineers and asking some to transition, learn about blockchain, and develop a proof of concept. Their titles might still just be software engineers.
>
> - Noah Marconi, Tag Innovation

LinkedIn's Emerging Jobs Report indicates that the number of blockchain developers grew by 33 times in 2018 in America, predominantly working for IBM, ConsenSys, and Chainyard.[51] While the Canadian landscape differs in size and company type, this job title is gaining increasing foothold as companies begin to search for development professionals who have some skillsets, self-taught or studied, that are blockchain-specific. In 2019, Deloitte reported that 46% of global enterprises surveyed were looking to hire staff with blockchain-specific experience.[52]

Education: Industry members consulted by ICTC agreed that education in Computer Sciences, Engineering, and Mathematics were useful for blockchain development. However, respondents differed on whether a minor or personal interest in Economics would be useful for blockchain developers.

Salary: While data on salaries was not expressly collected, several estimates for salaries of blockchain personnel exist. Specifically, for blockchain developers, American estimates range from US $125,000 to $175,000 median or average salary, depending on source.[53] In Canada, the Blockchain Research Institute's survey respondents reported an average salary of $98,423, but this figure does not differentiate between technical and non-technical roles.[54]

Individual learning: Respondents' opinions differed on whether blockchain developers could be self-taught (i.e., without a degree in software development or engineering). While some said that anyone could teach themselves to program effectively, others felt that a lack of formal computer sciences education led to flaws in code except in the case of a few exceptional individuals. As the industry matures, formalization of blockchain education is likely to increase; for the moment, however, interviewees highlighted a lack of widely-recognised blockchain credentials, which meant that senior blockchain staff often transitioned from more traditional computer science roles.

Learning on the job is still essential: Even with strong technical backgrounds, most software developers encountering blockchain for the first time will build most of their blockchain-specific skills in the workplace.

> At the last position I was in, we had almost no people come in with blockchain experience, we had to hire people who didn't have that experience but learned on the job. With that talent shortage, companies willing to take that leap and train people will benefit the industry as a whole.
>
> – Keegan Francis, Atlantic Blockchain Company

[51]"LinkedIn 2018 U.S. Emerging Jobs Report," LinkedIn, Dec 13, 2018,
    https://economicgraph.linkedin.com/en-us/research/linkedin-2018-emerging-jobs-report
[52]Deloitte, 2019, p. 43.
[53]ConsenSys, 2019, p. 7.
[54]"Canadian Blockchain Census 2019," Digital Chamber of Commerce Canada, Oct 2019,
    https://digitalchamber.org/wp-content/uploads/2019/10/Blockchain-Census_FINAL-Oct4-8.28.pdf p. 17

What skills does a blockchain developer need?

Top Ten Skills Extracted from Technical Blockchain Job Postings	Canadian Interviews & Focus Groups (order not significant)	CONSENSYS Blockchain Developer Job Kit	LinkedIn 2018 U.S. Emerging Jobs Report [55]
1 Blockchain	Blockchain or Protocol-Level Experience	Cryptography**	Solidity †
2 Cryptocurrency	Full-Stack Development	Blockchain Knowledge***	Blockchain
3 Ethereum	Smart Contract Programming	JavaScript	Ethereum
4 JavaScript, React.js	Experience with Enterprise-Scale Deployment & Legacy System Integration	Python	Cryptocurrency
5 Agile Software Development	Back end software development	Solidity	Node.js
6 Java	Game Theory & Economics	Back end languages****	
7 Python	Database Management & Architecture		
8 Hyperledger	JavaScript & Node.js		
9 Node.Js	User Experience Design		
10 Application Programming Interface	C++ Development		

See Appendix I for a discussion of methodology.

Specific skills in Cryptography for ConsenSys include: Public Key Encryption; Private Key Encryption; Key Agreement/Exchange; Digital Signatures; Hash Functions; Ring Signatures; Zero Knowledge Proofs; Encrypted Storage; Elliptic Curve Encryption; and Trusted Execution Environments.

**** Includes Consensus Algorithms; Miners & Security Incentivization; Proof of Work vs. Proof of Stake; Smart Contracts; Transactions, Gas, and Gas Prices; Sharding; Scalability Trilemma; Token Standards.***

***** Includes Go, rust, Java, .NET, C++, and Ruby.***

† Solidity is a programming language for implementing smart contracts, designed to work with Ethereum but applicable to other blockchain platforms.

[55]LinkedIn, 2018, https://economicgraph.linkedin.com/en-us/research/linkedin-2018-emerging-jobs-report

Blockchain Solutions Architects

Unlike many other technologies, designing or selecting a blockchain protocol is inextricably connected with its eventual business case. Many interviewees commented on the importance of finding a talented solutions architect who had a strong technical understanding, creativity, and an infallible sense of business cases, incentive structures, economics, and governance or legal requirements.

What skills does a proficient solutions architect have?

As illustrated in Figure 20b's presentation of job postings, solutions architects are the second-most in-demand blockchain professional in Canada following the broad category of "blockchain developer" and the more granular titles it implies. Industry consultants and educators described the skills needed to be a solutions architect (typically for enterprise) in a variety of complementary ways:

> [An important skillset is] really understanding how a blockchain solution can be developed and serve an entire industry, because it's not just a solution for one company but a system for a broad ecosystem of organizations. Having that business acumen is often overlooked but really necessary.
>
> – Mike Brown, ATB Financial

> People who can look at a problem space, what is an enterprise trying to achieve, what social or business goal do they have, and then come up with a solution using blockchain tech.
>
> - Victoria Lemieux, University of British Columbia

> There is both app design from a UX/UI standpoint, but also design in terms of what is the function, why are we building it, how is it useful? Does it have a functional use to people?
>
> – Iliana Oris Valiente, Accenture

> Everything blockchain is comprised of was there before, the innovation is putting those things together, this leap of faith, and understanding how to create value. A computer scientist doesn't know how to put these ingredients together. For someone to be efficient in this industry, they need to know economics and game theory, so it's a mix of values… Today what I hear from companies is that it's hard to employ people because people need holistic knowledge.
>
> - Andreas Veneris, University of Toronto

According to interviewees, successful solutions architects will have the following competencies:

- Knowledge of enterprise architecture

- Knowledge of market and competition

- Knowledge of the technology and its limitations

- Knowledge of data architecture considering privacy regulations

- Knowledge of incentive structures

- Strong creativity, novel thinking

- Ability to articulate the value of a new technology to an organization

- Experience developing PoCs

Other Blockchain-Specific Roles

Information Governance Professionals

Given the new regulatory landscape created by blockchain and its relationship with privacy legislation, securities regulation, and more, a new body of information governance and legal professionals are needed to help understand, audit, and regulate blockchain. Interviewees commented that professionals working in this space often have backgrounds in law, policy, or information sciences; knowledge of PIPEDA and GDPR; and knowledge of AML and KYC regulations, among other highly specialized knowledge. George Brown's blockchain developer program has introduced a course, Laws and Regulations,[56] to help new entrants into the blockchain labour market understand this field.

Blockchain Marketing Professionals

Beyond developing strong business minds for solutions architecture, businesses may also need to develop marketing professionals with technology knowledge. Particularly for emerging technologies, clients may or may not fully understand the blockchain solutions in the marketplace, and the organizations selling these solutions need people who are able to articulate their value.

> Business grads with a technology focus are key: it's difficult to articulate and present blockchain to a group of clients, so the ability to market to multiple stakeholders at different levels of understanding is hugely valuable"
>
> – Peter Patterson, IBM Blockchain

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[56] *"Blockchain Development Program (T175)," George Brown College Full-Time Programs 2020-2021, p. 2.*
https://www.georgebrown.ca/uploadedfiles/ProgramPDFs/2020-2021/Arts,%20Design%20and%20Information%20Technology/T175-2020-2021.pdf

Blockchain Security Analysts and Auditors

Particularly for organizations working with high-stakes smart contracts that could go awry if incorrectly auto-executed, there is a market for blockchain and cryptocurrency security specialists who are able to examine a blockchain program for bugs before it is implemented. Furthermore, cybersecurity personnel with crypto-blockchain expertise are needed to help organizations avoid hacking—despite blockchain's "unhackable" reputation, issues with a platform's underlying code can render it vulnerable, and the infrastructure around even Bitcoin has proven susceptible to attack.[57] These professionals may be consultants selling security audits, dedicated enterprise-level cybersecurity professionals, or anything in between.

Front-End Developers with Blockchain Experience

Interviewees differed on whether their front-end development staff needed experience with blockchain. While some held the position that front-end developers could interact with their product without ever encountering something unfamiliar, others felt that it was better to find someone with blockchain knowledge due to a few differences between a blockchain API and a traditional database.

[57]Alyssa Hertig, "The Latest Bitcoin Bug Was So Bad, Developers Kept Its Full Details a Secret," Coindesk, Sept 21, 2018, https://www.coindesk.com/the-latest-Bitcoin-bug-was-so-bad-developers-kept-its-full-details-a-secret

Emerging Trends for a Maturing Industry

As an emerging technology, blockchain's economic impact is not yet quantifiable. While numerous enterprises are beginning to develop internal use cases, they are also just beginning to sell their blockchain platforms to clients, and the full results of blockchain's wider commercial dissemination may not be seen for years, or decades, to come. International research shows extreme variation in economic forecasting for blockchain: while one prediction estimates that the global blockchain market will reach USD $57.6 billion by 2025, (CAGR 69.4% 2019 – 2025)[58] another estimates that blockchain will add over $176 billion in business value by the same year.[59] However, despite this volatility, most sources concur that the industry is at a point of serious transition. ICOs are in decline and approaching zero activity, while traditional venture capital is displacing ICOs as the source of funding. Research by The Block Crypto shows that the number of ICOs peaked in December 2017 and January 2018 at roughly 50 per month, before declining to close to zero by 2019.[60]

Selling at the Peak

Gowling WLG Canada was one of the country's first law firms to develop expertise in blockchain and help companies, industry players, such as banks and investors comply with anti-money laundering (AML), securities, tax, and other regulations. Tax lawyer Laura Gheorghiu has been working on cryptocurrency and blockchain-related files since 2016, and recalls an experience from the height of Bitcoin mania:

> A young man walked into our office one day, he was 22, and had made $16 million on bitcoin. A few years before, he had mined bitcoin as a past-time using his school computers, like a game. He had sold the bitcoin at the height of the boom and now he was a multi-millionaire. That was the promise of blockchain in 2017; the reality in 2019 is strikingly different, but it's a good story because now the kids have been scared away and the adults are in the house. The industry is slower moving now, but it is much more sustainable.

[58]Grand View Research, Blockchain Technology Market Size Share, & Trends Analysis Report By Type, By Component, By Application, By Enterprise Size, By End Use, By Region, And Segment Forecasts, 2019 – 2025, July 2019
https://www.reportlinker.com/p05807295/Blockchain-Technology-Market-Size-Share-Trends-Analysis-Report-By-Type-By-Component-By-Application-By-Enterprise-Size-By-End-Use-By-Region-And-Segment-Forecasts.html?utm_source=PRN
[59]Gartner Newsroom, "Gartner Predicts 90% of Current Enterprise Blockchain Platform Implementations Will Require Replacement by 2021," Stamford, Conn., June 2019.
[60]Larry Cermack, "A post-mortem on the ICO bubble: at least 89% of ICOs are in the red," The Block Crypto, August 2019,
https://www.theblockcrypto.com/genesis/35090/a-post-mortem-on-the-ico-bubble-at-least-89-of-icos-are-in-the-red.
Figures can also be seen here: https://twitter.com/lawmaster/status/1159130023963561984

After steep declines in public and private optimism following the "cryptowinter" of 2018, sanguine blockchain entrepreneurs and quietly determined business units within larger firms have set about separating the value-adding use-cases from the irrational exuberance of the pre-cryptowinter period.[61] Figure 23 shows that public interest in blockchain peaked in early 2018, just following the peak in ICO activity and the price of Bitcoin in late 2017. Graphs for keywords 'Ethereum,' 'Cryptocurrency,' and 'Bitcoin' look similar.

Figure 23: *Blockchain Search Intensity in Canadian Provinces*
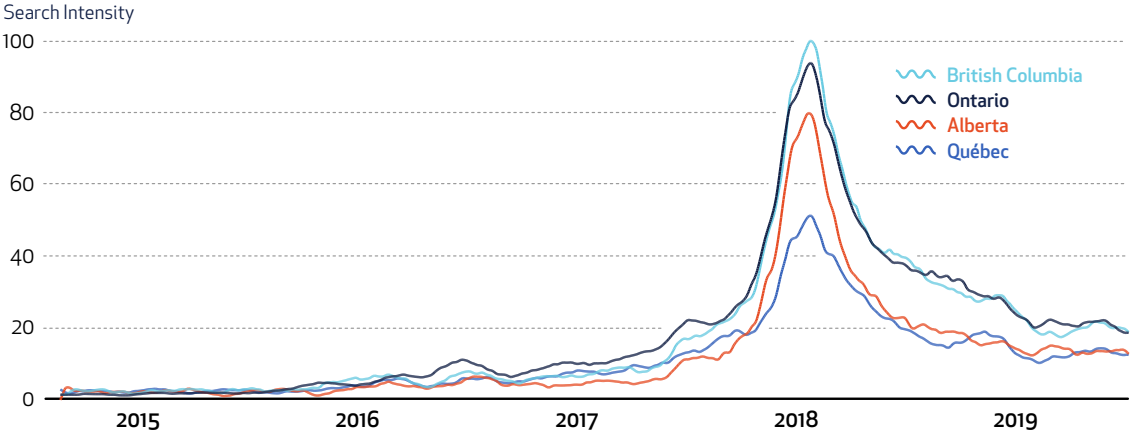
Note: "Search Intensity" is normalized to 100 for the province and date where the keyword represents the highest proportion of total searches. Trendlines have been smoothed with a moving average for clarity.

Academic interest in blockchain can also be assessed by analysing Google Scholar results for journal articles containing the keyword "blockchain" in either the text or title, as shown in Figure 24. Forecasting the value for 2019 based on the first 7 months of the year, continued growth is estimated in the number of new articles being created, but at a slower rate than in previous years. Collectively, data on ICOs, Google Searches, and Google Scholar are suggestive of some slowing in interest in blockchain relative to the peaks in 2017. However, reports of blockchain's death are greatly exaggerated, and certain activities like ICOs, Google searches, and journal articles do not provide a complete picture. Indeed, while the price of Bitcoin is down from its peak of USD $17,000 in December 2017, it is up three times from its nadir of USD $3,300 in December 2018, reaching over USD $10,000 as of September 2019. To be quite explicit, Bitcoin's price partially indicates the market's expectation of future value, and therefore persistent value indicates that the market believes Bitcoin will continue to exist.

Figure 24: *Google Scholar Publications with Keyboard "Blockchain" (International)*
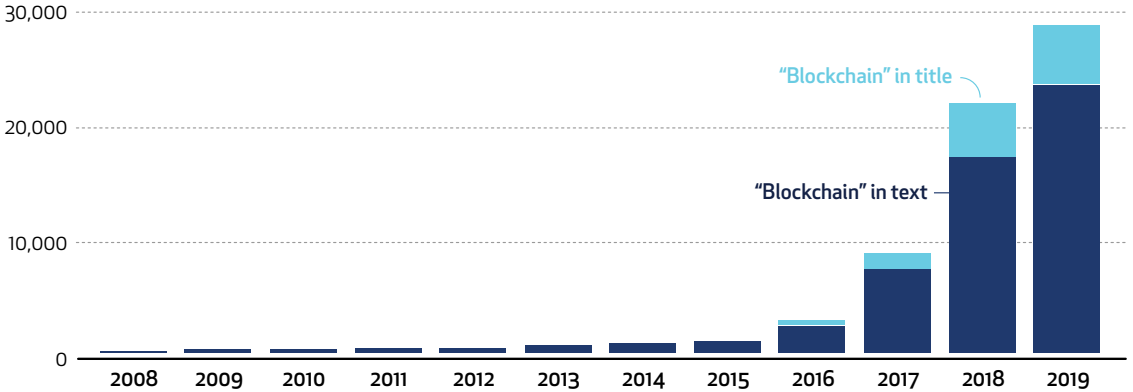
Source: ICTC 2019 Note: 2019 value indicates forecast based on first 7 months

[61] CB Insights, "Blockchain Trends in Review," 2019, https://www.cbinsights.com/research/report/blockchain-trends-opportunities/

A Familiar Trajectory: Blockchain, the Internet, and the Cloud

When asked to describe blockchain's maturity and projections for uptake, several interviewees noted its similarity to prior technologies, comparing it to "the beginnings of the Internet," drawing parallels between its trajectory and that of cloud computing, or placing it on a timeline with other emerging technologies (for example, commenting that it is "ten years behind AI").

The qualities that blockchain shares with the early stages of the internet are sometimes noted by developers who have seen their more isolated work on blockchain become mainstream: Ceit Butler, the co-founder of George Brown's Blockchain Developer program, noted that "it was like the rise of the internet: when I arrived it was early days and the space was very small. Bitcoin was this niche technology that only Libertarians and cryptographers were interested in, and then suddenly the price skyrocketed, digital currencies were in the mainstream news, and everyone had a coin," just as everyone in the dotcom boom suddenly had a website.

Similarly, Laurent Féral-Pierssens of Deloitte Blockchain Canada drew a comparison between the early innovators of blockchain and the internet, noting:

> We can compare this back to the early 2000s when HTML/PHP applications became mainstream. The technical barrier was quite low, but the mindset needed to innovate was drastically different from anything prior. It enabled a generation of entrepreneurs to build products from their dorm rooms, not the classroom. We are seeing the same thing with blockchain innovation. The technical knowledge required is quite low, especially compared to artificial intelligence. Once again, it is the mindset needed that is drastically novel. Innovation is once again happening in the dorm room, not yet in the classroom.

In another technological comparison, Iliana Oris Valiente of Accenture and ColliderX compared blockchain's development to that of cloud computing 15 years ago:

> While we're making progress towards production readiness and mainstream adoption, we're not there yet. As a comparison of how long it typically takes for technology to be adopted, let's look at the adoption of cloud tech. One would think that by today, in 2019, everyone would be on the cloud. However, many enterprise clients are still thinking about the cloud, creating their business case, and how to execute the journey to cloud - even though it has been over 15 years since the tech was introduced. So sometimes, I do think that the expectations of the blockchain industry and also the expectations that the external community has of this industry need to be tempered. It's unrealistic to expect that we're going to take a technology that breaks so many existing paradigms, and then overnight, just casually throw it into production. Adopting blockchain technology requires changes to many business models and sometimes changes to the dynamics of entire organizations. A more realistic expectation is that we're two or three years out from more uses that are officially and publicly in production.

Interestingly, industry consultants have suggested that the current era of blockchain research and development can be characterized by numerous PoC-stage ideas just beginning to be implemented. A time of pre-revenue, high-value intellectual property makes it difficult to assess the profile of blockchain innovation in private companies; however, measuring the number of new patents by firm size can shed some light on where innovation has occurred and will occur. Not all patents are equal in value, but their raw number across time hint at publicly visible, revenue-generating applications to come. In both Canadian and American patent data, it is possible to observe a trend in the proportion of patents by smaller firms (those with fewer than 10 employees) growing since at least 2017. In the Canadian data, many patents were filed by Toronto Dominion Bank in 2016 (20 patents), but since this date, the proportion of new patents going to smaller firms has increased. Thus, by 2018, half of all patents were owned by companies smaller than 1000 employees, and over a third were owned by firms with 10 or fewer employees.

Figure 25: *Percentage of Canadian Patents by Company Size*
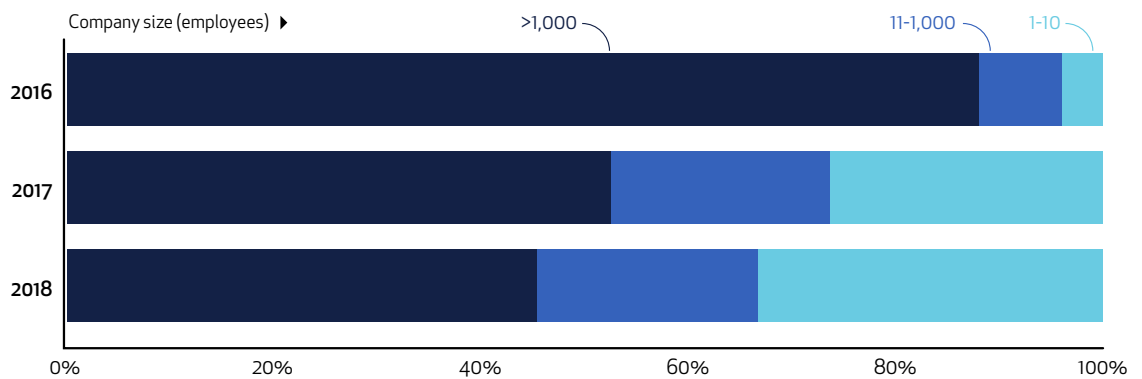
Source: Canadian Intellectual Property Office

Thus, while bigger firms have owned the majority of all patents in the USA and Canada since 2016, we are witnessing a return to a period where the majority of all patents are owned by firms with fewer than 1000 employees, and over 25% are owned by firms with less than 10 employees. This trend may indicate a growing business maturity among small firms.

Platform Scalability, Security, and Interoperability: Transitions in Technological Maturity

A key part of becoming a mature, user-friendly technology for blockchain is improving scalability, security, and interoperability. Several interviewees noted current hurdles to widespread adoption.

> Scalability and security will improve over time with public blockchains. For enterprises to use these public frameworks, when multiple parties are involved, the blockchain platform needs to comply with the data format and data governance policies of each party, which won't happen immediately, but there are a lot of people working on it. Standards for identity will also become a big part of the blockchain industry. Over time, for example, you will see secure identities for all the IoT sensors on a supply chain. Supporting infrastructure like digital identity will allow blockchain to become a full-fledged, trustable system.
>
> - Baiju Jacob, ChainDigit

> In the identity space, we're seeing a variety of platforms where users are populating identity management systems and building their credibility—but there is no universal standard. We're finding that we're forced to use closed systems and private blockchains that are creating a fragmented environment rather than a universal one, which is causing fragmentation as to where people store their credentials. It's like having multiple wallets. I'd like that resolved with an interoperable standard where credentials can be consolidated.
>
> - Alex Todd, ReliablyME

Organizations like the Blockchain Interoperability Alliance[62] and the Enterprise Ethereum Alliance,[63] both of whom have Canadian members, are working towards the technological innovations needed to improve blockchain interoperability.

[62]ICON Foundation, "Blockchain Interoperability Alliance: ICON x Aion x Wanchain," Medium, Dec 5, 2017,
  https://medium.com/helloiconworld/blockchain-interoperability-alliance-icon-x-aion-x-wanchain-8aeaafb3ebdd
[63]ConsenSys, "Enterprise Ethereum Alliance Releases New Standards for Blockchain Interoperability," Medium, May 13, 2019,
  https://media.consensys.net/enterprise-ethereum-alliance-releases-new-standards-for-blockchain-interoperability-c5dcea23ba8e

Figure 26 reinforces the evidence of blockchain industry maturation by showing the average age of blockchain technology and cryptocurrency firms in Canada since 2008[64] (excluding established firms that added a blockchain focus after its invention). While the average age of businesses declines after a start-up boom in 2016, in general the trend has been towards an ageing industry. Today, the average blockchain firm (or business unit) founded since 2008 is roughly 3 years old.

Figure 26: *Average Age of Blockchain Firms Founded Since 2008 (Canada)*
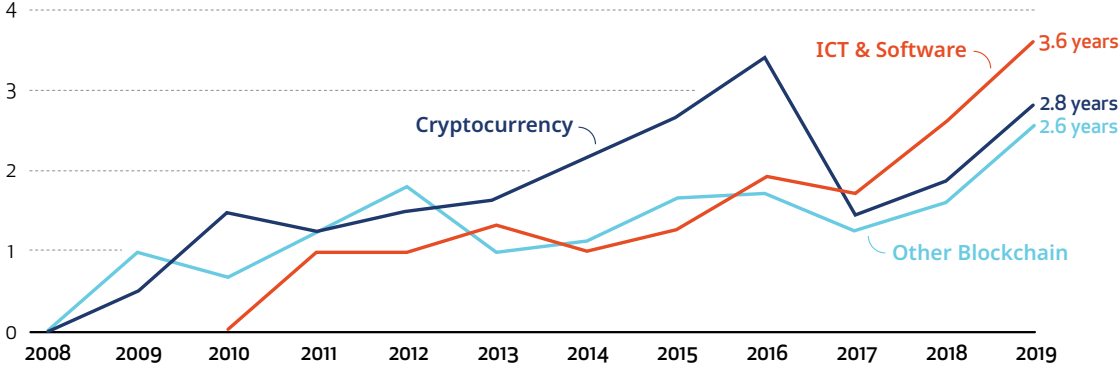
Source: ICTC Note: 2019 vlaue is based on first half of year

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[64]*Using sample set collected in this study*

Conclusion

For 10 years, blockchain has promised to remake the internet and facilitate a new way of trustlessly tracking ownership of valuable assets without costly middlemen. Its promises to remake business, finance, supply chains, or even society and democracy have attracted the attention of businesspeople, policymakers, and academics alike, and the volatile ride of cryptocurrencies in particular has captured the imagination of the public. Amid this widespread interest, this study aims to provide a comprehensive analysis of the blockchain ecosystem in Canada, including descriptions of the industry's particular characteristics across regions, analysis of employment, and other trends.

While there is blockchain activity across Canada, Toronto, and Vancouver are the dual cores of the blockchain economy in Canada. Together, these cities represent the location of about 65% of the country's blockchain workers, with top jobs including software developers and solutions architects, and other roles like information governance, security or auditing, and marketing professionals.

At the same time, the growth and maturity of the blockchain industry in Canada is set to scale. Despite the slower growth seen after a decline (tracking Bitcoin's price), collectively, the blockchain industry still shows signs of robust growth and maturation, with many use-cases approaching viability as PoCs are trialed. Although the number of new firms has steadied since 2016-17, the volume of employees has roughly doubled every year since 2015, and this trend does not appear to be abating. Building Canadian Consensus presents multiple kinds of evidence of maturation and diversification of the blockchain industry, with new applications in supply-chain, real estate, and healthcare starting to materialize within the last few years. The technology and industry of blockchain promises continued growth, disruption of old processes, and to continue to capture the imaginations of governments, entrepreneurs, and the public as unexpected new blockchain applications continue to be invented in Canada and internationally.

Appendix

Research Methodology

This study uses both **qualitative** and **quantitative** research methods to characterize the nature and trends within the Canadian blockchain ecosystem. The following section discusses the sources used and research limitations.

Primary sources

Qualitative

Key Informant Interviews. ICTC conducted 24 key informant interviews (KIIs) with a regionally diverse group of Canadian blockchain industry participants. Interviewees were first recruited through targeted outreach, followed by snowball sampling with purposeful selection for regional and industry representativeness. These interviews were tailored to collect information on organization description, how the organization uses blockchain technology, and the skills and job titles of their blockchain-related employees. In addition, interviewees addressed the Canadian blockchain ecosystem, including regional trends, trends over time, and business and regulatory considerations. Due to the blockchain industry's concentration in Ontario, about half of the interviewees were from the Greater Toronto Area or Ottawa. A further third of interviewees were from Quebec and British Columbia, the second two biggest blockchain hubs in the country, and the remainder of participants hailed from Alberta, Saskatchewan, and Nova Scotia. Interviewees' suggestions and insights guided the qualitative description of the blockchain ecosystem in Canada, as well as identifying novel sources of quantitative data.

Advisory Committee. ICTC also hosted two advisory committee group meetings of 11 industry consultants, of which 4 also participated in the interview process, wherein initial data and results were presented. The advisory group met twice during the course of the project to provide additional resources where necessary, evaluate research progress, and validate findings. These meetings occurred between April and October 2019. Experts participating in KIIs and the advisory committee meetings included founders, directors, chief technology officers, consultants, and others, from start-ups, SMEs, large enterprises, or not-for-profit organizations.

All interviewees and committee participants acknowledged in this report are cited with their permission. Several participants preferred to remain anonymous, and their contributions have been used only in aggregate findings.

Additional Consultations. Throughout the course of the study, ICTC consulted with industry representatives as a part of ongoing outreach. Several industry representatives offered secondary resources and reading, or reached out to request an interview, connection, or update on the study.

Quantitative

Company-level web scraping. Key players within the blockchain ecosystem in Canada were identified through a rigorous web scraping approach. Companies that were headquartered in Canada and had Canadian employees were included, with investigations of various websites used to measure company activity. Company-level data included founding years, location, and industry. The search excluded duplicate companies, companies that appeared to no longer be active, or companies that appeared to be false positives (i.e., using blockchain keywords in marketing materials or articles, but without offering a service or product related to blockchain). Companies that had blockchain units within larger organizations (e.g., a blockchain R&D unit in a bank) were included in the web scraping process.

Employee web scraping. A database of information about Canadian blockchain company employees was generated based on publicly available data. Job history, job titles, education (institution, degree, and field of study), and gender were collected. ICTC has anonymized this data and used it in aggregate for all results.

Job postings. Blockchain-related technical job postings in Canada were collected in a snapshot in mid-September, 2019. These results were used in aggregate for demand analysis.

Secondary sources

Literature scan. A thorough review of global and Canadian blockchain literature was conducted to establish study baselines. The literature review helped shape research methods and questions, while providing a useful understanding of current issues in blockchain technology, related skills and jobs, and key industry participants. The review allowed ICTC to identify initial interviewees, advisory committee participants, and form a web scraping methodology to examine both startups related to blockchain and blockchain business units within larger, pre-existing organizations.

In addition to the literature review, ICTC accessed publicly available secondary data sources including Canadian and American patent data (with the keyword "blockchain," gathered August 26th, 2019), Google trends data (with the keyword "blockchain," gathered August 22nd, 2019), and data from Meetup.com.

Meetup data appears in Figure 8 and was gathered on August 06, 2019. The search terms "blockchain," "Bitcoin," "Ethereum," and "Hyperledger" were used for each provincial and territorial capital city, in addition to large cities within each province other than the capital (for example, Toronto, Calgary, Vancouver, and Saskatoon). The search gathered data on the largest meetup for each search term, the number of members in each meetup, and the most recent percent attendance as reflected by Meetup RSVPs. Results were adjusted for population based on the 2016 census.

Research Limitations

While efforts were made to mitigate biases or knowledge gaps in the report, uncertainty and estimation are both inevitable within research on such a new technology. The following section discusses several limitations embedded in the study.

Web extraction: While all efforts were exerted to ensure that only the Canadian ecosystem was included in the report, throughout the web scraping process, ICTC assumed that employees associated with a company are located at the headquarters of the company. This may not always be the case, if many employees work remotely for instance, but it served as an approximation. Web-scraping occurred over a three-month period of time, between May and July 2019. While the study attempts to extract data as time-series from 2015 to the present, ultimately the figures in ICTC's analysis for 2019 were either incomplete or estimated/forecasted, depending on the purpose of the figure. Likewise, early data from 2015 may underestimate the number of employees and companies, as individuals or firms that left the blockchain ecosystem without online relics of their presence would not have been detected using these methods. Finally, it is also possible that not all blockchain workers or companies in Canada have made their materials publicly available online.

Data: Existing research and data on blockchain in Canada is highly scarce and preliminary. ICTC endeavored to gather data from as many diverse sources as possible to provide a holistic picture of the blockchain ecosystem: several potential sources of data, such as GitHub, proved rich in general but difficult to limit to Canadian contributions. As a result, research in further years may build on this study and fill in gaps in data or methodology as time goes by and more data about blockchain in Canada becomes available.

Forecasting: Due to the novelty, volatility, and complexity of the blockchain ecosystem, as well as limited data, forecasts are unlikely to be accurate. Blockchain employment, companies, or usage does not follow a predictable enough pattern for long-term forecasts to be meaningful, although ICTC sometimes conducts very short-term forecasts for the remaining months of 2019 within this report.
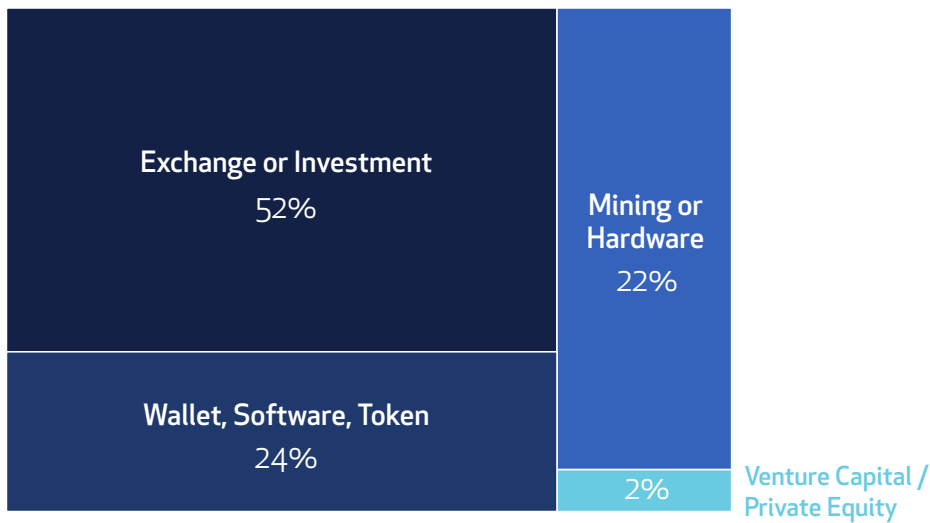
III Additional Figures

This section includes additional figures on patent data for those interested in more context.

Cumulative Canadian Patents by Company Size (total)
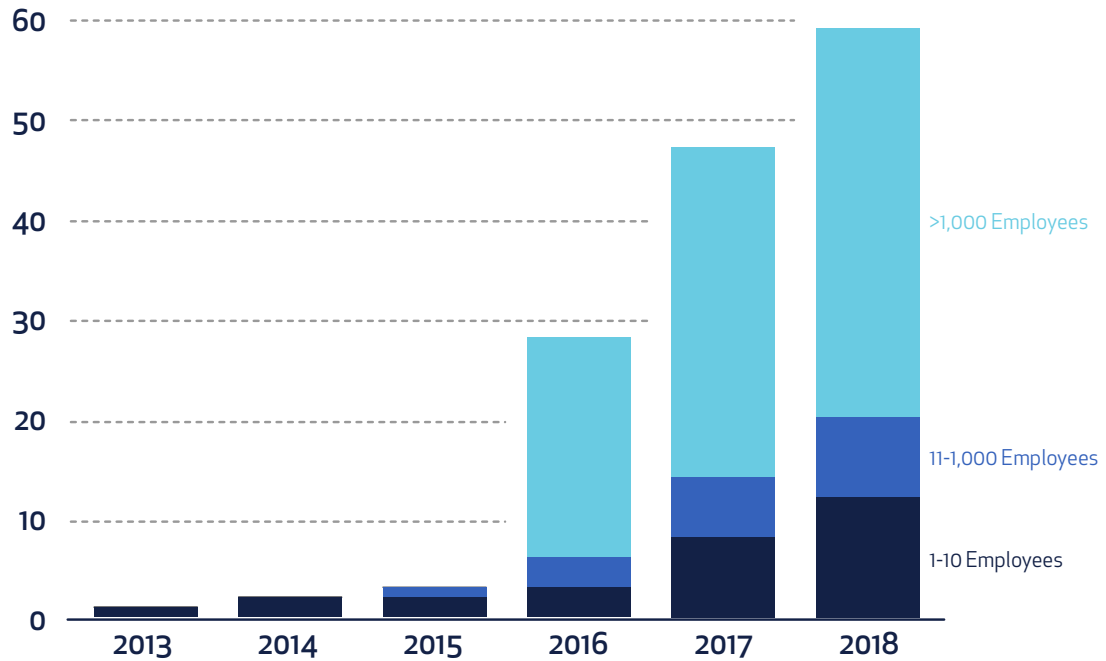
Source: ICTC Note: 2018 value is likely underestimated due to slow patent processing

Cumulative Canadian Patents by Company Size (percent of all companies)

Source: ICTC