Towards just and resilient supply chains for the digital CBD

RMIT Blockchain Innovation Hub
RMIT Centre for Cyber Security Research & Innovation
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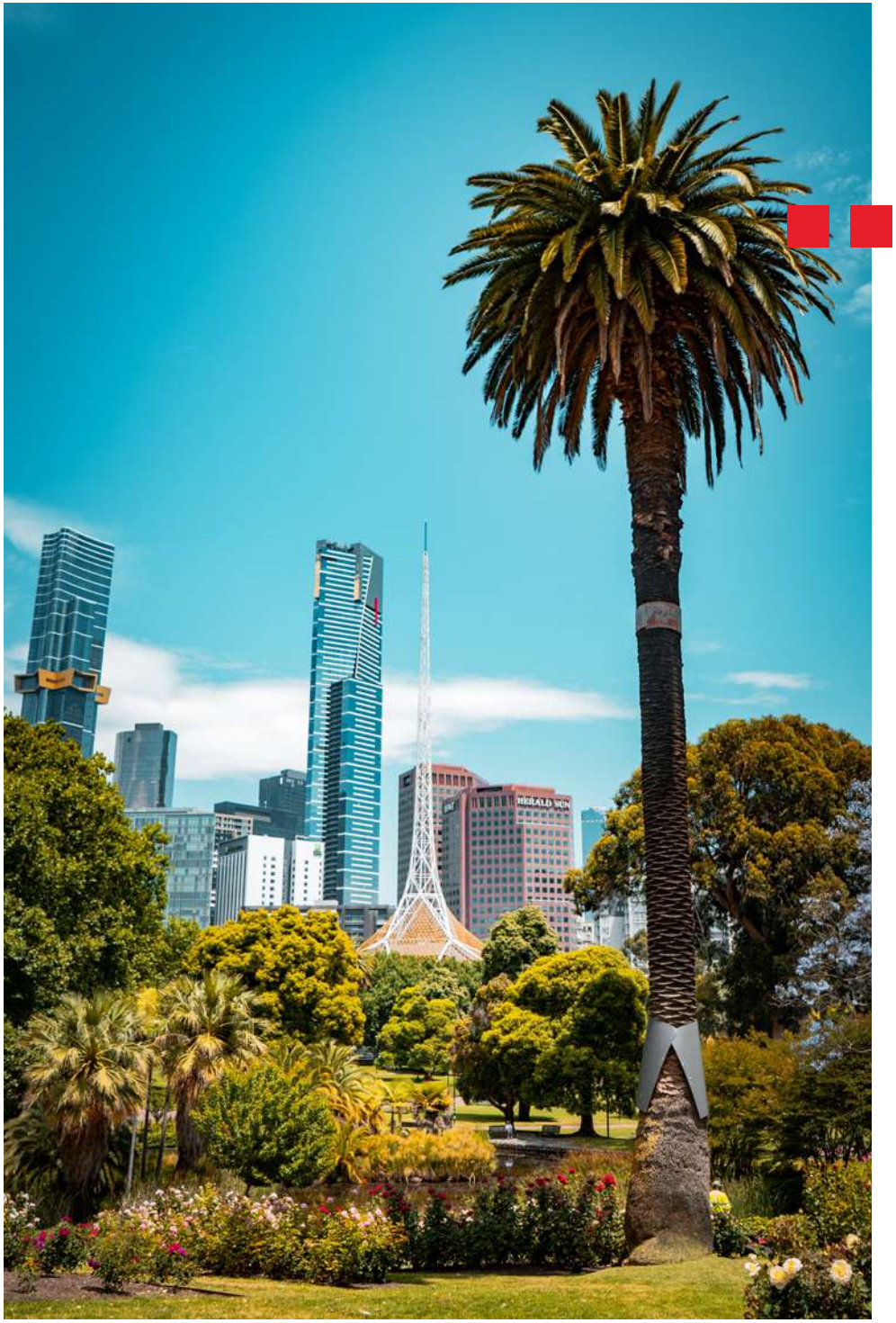

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Foreword

from Associate Professor Chris Berg

Associate Professor Chris Berg

Until the COVID-19 pandemic, how supply chains were organised and maintained was hardly viewed as a central public policy issue. Nor should it be admitted, were supply chains a central focus for social scientists. Other than specialisations such as logistics, other fields had a habit of abstracting the complexity and tangibility of supply chains away from their thinking. The pandemic has shown us that supply chains matter, and both policy actors and scholars need to bring the complex supply chain networks into their understanding of the economy.

On the one hand, it has been remarkable how well supply chains have adapted to the pandemic shock. Despite many predictions of catastrophe, the supply of consumer goods has been almost entirely unabated. While in-store shortages of consumables like toilet paper received much press, those shortages turned out to be short-lived and almost entirely driven by consumer panic than dysfunctional supply chains.

On the other hand, the pandemic significantly disrupted advanced and complex manufacturing. Computer chip shortages have affected almost every downstream industry in some way, leading delays and costs in equipment provision across the global economy. But again, the causes of these shortages is not easy to disentangle – geopolitical issues such as the US-China trade war and more recently the invasion of Ukraine have also disturbed the production and flow of chip components.

This report is part of the Digital CBD program – a joint project bringing together researchers across RMIT University from RMIT's Blockchain Innovation Hub, Centre for Cyber Security Research and Innovation, and Digital Ethnography Research Centre – to understand the impact of the pandemic and digital change on Melbourne's CBD.

The program has been supported by the Victorian Government's Victorian Higher Education State Investment Fund.

At first glance, a single city might be a strange framework to think about supply chains when we associate supply chains with large scale global networks rather than the urban and suburban environments of a city. But as this report shows, the city is shaped by supply chains both large and small. As economic activity shifts, as it did during the pandemic, so too supply chains are restructured around the new demands and environments. It was not simply supply issues that caused supply chain backlogs for computer chips, it was a jump in demand for the equipment that allowed work from home in a digital environment.

In this report, the authors compellingly set out the challenges posed by supply chain disruption during the pandemic and explore how to develop supply chains that are resilient, adaptable and responsive to social needs. Most importantly, they outline how new technologies such as blockchain and artificial intelligence can facilitate innovation in supply chains that provides greater resilience and adaptability.

Associate Professor Chris Berg
Co-Director RMIT Blockchain Innovation Hub

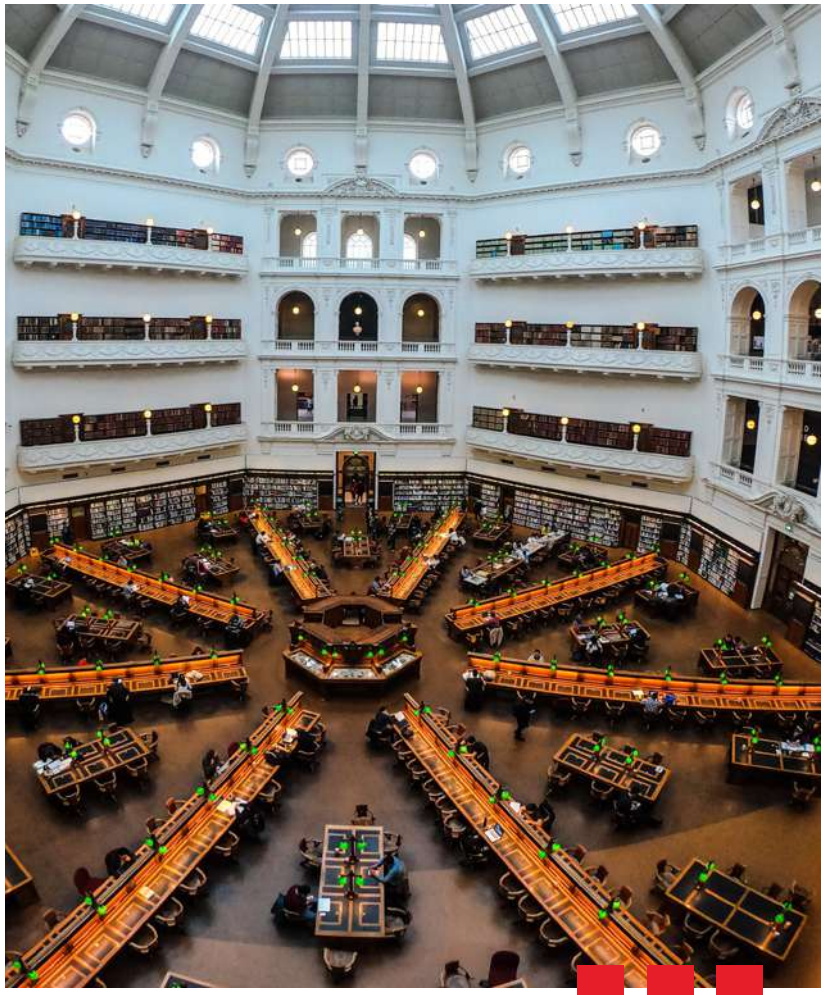
Executive summary

This report provides a strategic analysis on developing resilient and just supply chains for a digital CBD

In this report, the third in the Digital CBD research series, we explore how to utilise innovative emerging technologies such as blockchain technology, Artificial Intelligence (AI) and Machine Learning (ML), Internet of Things (IoT) and their applications to address the supply chain challenges and cybersecurity risks within the context of a CBD.

By following an interdisciplinary approach, we have combined the knowledge and advancements from multiple disciplines such as cyber security, information technology, supply chain management and economics, to highlight the issues, challenges and opportunities for Melbourne to transition towards a digital CBD.

The Melbourne CBD is known as Melbourne's business and financial centre. The twin shocks of the COVID-19 pandemic and the rapidly accelerated technology adoption have radically changed the way supply chains operate which in turn have significantly impacted the overall consumer experience of Melburnians.



We look back at the impact of the COVID-19 pandemic response on supply chains, and find that supply and demand shocks are caused by four key supply chain issues being:

1. **Sudden work-force shortages.**
2. **Transportation and logistics disruptions.**
3. **Insufficient knowledge across the full supply chain network.**
4. **Increased number of security breaches and attacks in digital supply chains.**

Executive summary

This report aims to explore two research objectives. The first objective is proving a deeper understanding of the issues and challenges supply chains faced due to the twin shocks. The second objective is to explain how emerging technologies and other digital infrastructures can be used to build secure digital supply networks that can reduce the information asymmetries and enhance collaboration, agility and optimisation whilst embedding just and fairer practices into digital processes.

We look at three supply chain case studies and the unique challenges they faced during the pandemic, then we examine how to leverage emerging technologies in the Web3 space to address these supply chain challenges including blockchain, smart contracts, NFTs, verifiable credentials, TradeTech, IoT and smart sensors, autonomous vehicles and robotics, drones and AI/ML for forecasting.

The Solution:

Recommendations

Finally, out of the findings of this report, we propose the following six recommendations for the government to action:

Recommendation 1:

Supply chain data governance framework.

Recommendation 2:

Standardise supply chain cyber security requirements.

Recommendation 3:

NFTs as digital twins.

Recommendation 4:

Melbourne as a testbed for autonomous vehicles.

Recommendation 5:

Uplift digital skills within supply chains.

Recommendation 6:

Develop a blockchain pilot for a Victorian supply chain.

Introduction

Supply chains are known as the lifeblood of a resilient economy

The COVID-19 pandemic highlighted vulnerabilities in supply chains both at national and global levels.[1] It opens up conversations around how we can best deal with supply and demand shocks in a just and fair way into the future. First, we experienced a substantial supply shock that affected many global supply chains.[2] Then with purchase limitations and panic buying, demand shocks continued to disrupt the global economy and supply chains within it.[3] During the past two years, businesses had to endure numerous supply and demand uncertainties, as well as logistic disruptions that caused a significant impact on businesses and access to goods and services for end consumers.[4]

In Australia, Victoria is one of the states which is known as an attractive place for businesses to locate. Victoria's supply chain and logistics industry contributes approximately A$21 billion per year to the economy and employs around 280,000 people.[5]

Melbourne is also strategically located with major ports, roads, rail, airports and transport hubs well networked to move products among local, regional, interstate and global markets.

For instance, the Port of Melbourne is Australia's largest maritime hub which holds an economical significance to the businesses across Victoria and south-eastern Australia.

The Port of Melbourne contributes $6 billion each year to Victoria's economy.

Victoria's commercial ports (Port of Melbourne, Port of Geelong, Port of Hastings, Port of Portland) collaboratively support Australian businesses by handling around $26 billion worth of local exports and almost a quarter of Australia's total food and fibre exports.[6]

Therefore, with larger population and transportation infrastructures, Victoria has become a prominent transport and logistic hub in Australia with Melbourne at the centre of several key supply chains.

[1] Thilmany, D., Canales, E., Low, S. A., & Boys, K. (2021). Local Food Supply Chain Dynamics and Resilience during COVID-19. Applied Economic Perspectives and Policy, 43(1), 86–104. https://doi.org/10.1002/aepp.13121
[2] Fonseca, L. M., & Azevedo, A. L. (2020). COVID- 19: outcomes for Global Supply Chains. Management & Marketing (Bucharest, Romania), 15(1), 424–438. https://doi.org/10.2478/mmcks-2020-0025
[3] Bhattacharya, S., Smark, C., & Mir, M. (2021). COVID 19: Social, financial and economic implications. Australasian Accounting, Business & Finance Journal, 15(1), 1–4. https://doi.org/10.14453/aabfj.v15i1.1
[4] Ibid
[5] https://www.theguardian.com/business/2022/jan/12/job-vacancies-surge-in-australia-as-covid-labour-shortages-choke-supply-chains
[6] https://transport.vic.gov.au/ports-and-freight/commercial-ports

Melbourne CBD is also known as the fastest-growing small area of Australia

The series of lockdowns Melbourne has experienced in the last two years, resulted in the heart-breaking outcome of seeing some of our favourite shops and restaurants closing permanently or barely surviving. The 'work from home' recommendations[7] and the self-imposed 'shadow' lockdowns[8] were also disrupting factors affecting the economic stability of Melbourne. For instance, data from the City of Melbourne pedestrian sensors have reported an almost 70% reduction in foot traffic within the Melbourne Central Business District (CBD),[9] compared to 2019, destroying businesses and transforming Melbourne into a 'ghost town'.[10]

Cities are the junction points where all value passes through and supply chains meet, build business relationships and coordinate economic activities.[11]

Through these coordinated economic activities, supply chains also connect cities together economically interrelating cities and supply chains.[12] Primarily, both cities and supply chains consist of people, businesses and data as key components. When cities are disrupted, supply chains also get disrupted and vice versa. With rapid technology adoption, both cities and supply chains are on their way to becoming fully digitalised. As a result, cities and supply chains both have experienced a similar set of challenges during the past two years. Interestingly, the strategic directives that cities and supply chains have to consider in order to overcome these challenges, are also the same.

In this report the following terminologies will be used frequently. We define them to guide the reader:

Melbourne CBD:

The Melbourne CBD is known as Melbourne's business and financial centre with retail, restaurant and other services offered throughout the day. The CBD is also known as the fastest-growing small area of Australia with the highest number of businesses and residents.

Supply chain:

Management of upstream and downstream relationships with suppliers and customers in order to deliver superior customer value at less cost to the supply chain as a whole.[13] The goal of a supply chain is to ensure that the products and services are efficiently and effectively flowing from the producers to consumers by creating a collaborative network of business entities. Traditionally, a 'supply chain' can be defined as a "linear chain of suppliers, where one organisation feeds resources or materials into another". However, especially in modern supply chains, we can also see 'networks of multiple and bidirectional interdependencies between organisations'.[14]

[7] https://www.pc.gov.au/research/completed/working-from-home
[8] https://www.news.com.au/national/victoria/politics/premier-responds-to-criticism-victorias-covid-restrictions-are-shadow-lockdown/news-story/35dd8cf04db8f75e67f073b0e869774d
[9] https://www.heraldsun.com.au/coronavirus/worker-loyalty-scheme-plan-to-rescue-melbourne/news-story/fc5cabfecb93fede437566af23defd77
[10] https://www.9news.com.au/national/victoria-lagging-behind-some-australian-states-in-covid19-booster-rollout/5a0d9cb2-6490-40f9-8797-6efd66bf4c1a
[11] Rodrigue, J.-P. (2012). The Geography of Global Supply Chains: Evidence from Third-Party Logistics. The Journal of Supply Chain Management, 48(3), 15–23. https://doi.org/10.1111/j.1745-493X.2012.03268.x
[12] Ibid
[13] Christopher, M. (2016). Logistics & supply chain management. Pearson UK.
[14] Garnett, P., Doherty, B. & Heron, T. Vulnerability of the United Kingdom's food supply chains exposed by COVID-19. Nat Food 1, 315–318 (2020)

Resilience in supply chains:

A resilient supply chain has the ability to quickly return to its original state or move to a new, more desirable state after undergoing a shock'.[15] We encountered this in the ongoing supply chain crisis because local supply chains were not equipped to adequately respond to the demand and supply shocks they underwent. Usually, the traditional supply chains that follow linear business processes are known to be less resilient towards these challenges because they consist of tightly coupled business processes.[16]

As a downstream consequence of the complex interdependencies between these tightly coupled supply chain networks, they end up deadlocked waiting for each other to resolve their supply chain disruptions.[17] Therefore, during the last decade, many organisations have begun to invest in digital supply chain networks that are more resilient to these disruptions.

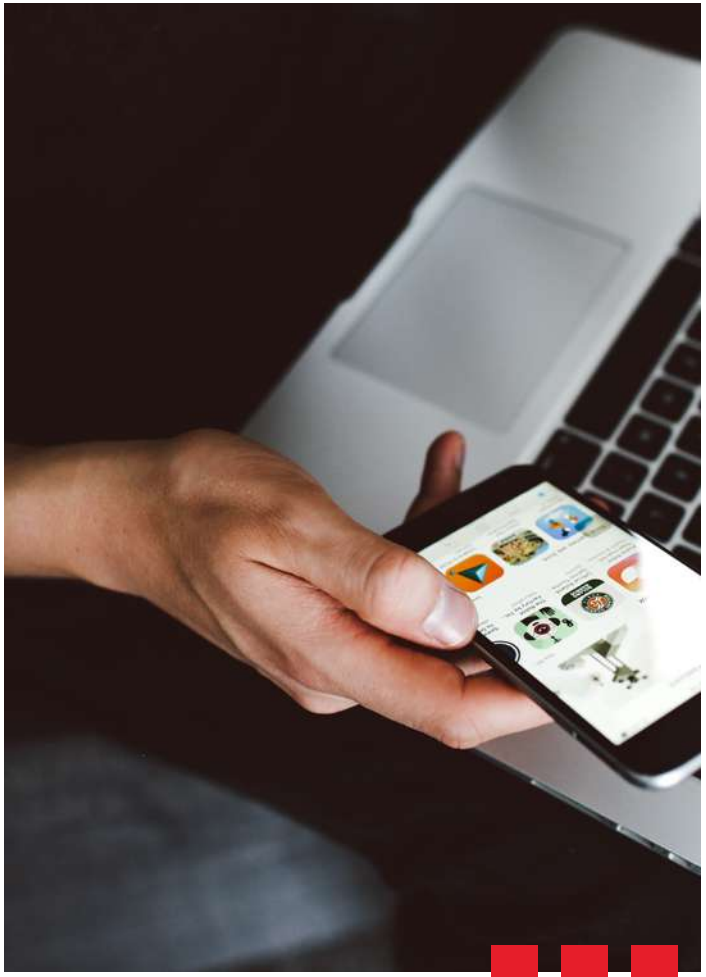
Digital supply chains:

A digital supply chain is defined as an intelligent best-fit technological system that is based on the capability of massive data disposal and excellent cooperation and communication for digital hardware, software, and networks to support and synchronise interaction between organisations by making services more valuable, accessible, and affordable with consistent, agile and effective outcomes.[18]

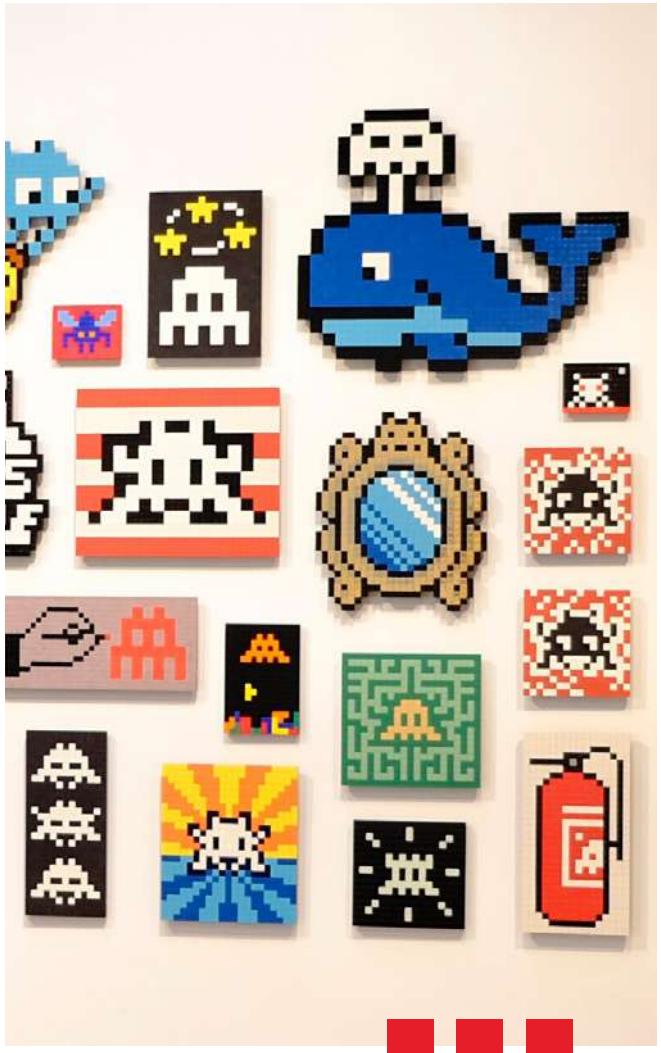
Digital supply chains are not about whether goods and services are digital or physical, it is about how supply chain processes are managed across a wide variety of innovative technologies.[19] Digitalisation refers to the impact of these technologies, caused by adoption and operation, in organisational and societal perspectives.[20]

With the rapid digital acceleration through **Web3 and Industry 4.0**, modern supply chains are now exploring far more advanced technologies such as Artificial Intelligence (AI), blockchain technology and Internet of Things (IoT) to manage and monitor the supply chain processes.

These technologies have become essential when undertaking real-time planning, forecasting, warehouse and inventory management, transportation and delivery of products.[21] The insights gathered through business intelligence systems that are linked to supply chains can be used to forecast the demand as well as the supply of products and services which are vital to creating more resilient supply chains.[22] Irrespective of the disruptions caused by COVID-19, companies have continued to invest in their technological infrastructures and digitising supply chain operations.



[15] Christopher, M., & Peck, H. (2004). Building the resilient supply chain
[16] Christopher, M., & Holweg, M. (2017). Supply chain 2.0 revisited: a framework for managing volatility-induced risk in the supply chain. International Journal of Physical Distribution & Logistics Management, 47(1), 2–17. https://doi.org/10.1108/IJPDLM-09-2016-0245
[17] Garnett (n 14)
[18] Büyüközkan, G. and Göçer, F. (2018), "Digital supply chain: literature review and a proposed framework for future research", Computers in Industry, Vol. 97, pp. 157-177, doi: 10.1016/j. compind.2018.02.010
[19] Ibid
[20] Queiroz, M. M., Pereira, S. C. F., Telles, R., & Machado, M. C. (2019). Industry 4.0 and digital supply chain capabilities: A framework for understanding digitalisation challenges and opportunities Benchmarking : an International Journal, 28(5), 1761–1782. https://doi.org/10.1108/BIJ-12-2018-0435
[21] Ibid
[22] Ardito, L., Petruzzelli, A. M., Panniello, U., & Garavelli, A. C. (2019). Towards Industry 4.0: Mapping digital technologies for supply chain management-marketing integration. Business Process Management Journal, 25(2), 323–346. https://doi.org/10.1108/BPMJ-04-2017-0088



Industry 4.0:

Industry 4.0 is the fourth industrial revolution which involves the development, merchandising and operation of autonomous, knowledge- and sensor-based, self-regulating production systems. The opportunities and benefits that are anticipated to come along with Industry 4.0 seem to be manifold, resulting in highly flexible mass production, real-time coordination and optimisation of value chains, reduction of complexity costs or the emergence of entirely new services and business models.[23]

Blockchain and smart contracts:

A blockchain is a distributed and decentralised database that supports immutable data records and tracking digital assets in business networks.[24] It has the ability to secure data records and facilitate trustworthy interactions without relying on a third party. Smart contracts are pieces of software stored on the blockchain that control the transfer of assets between parties under certain conditions.[25] They are business agreements that are written as code and deployed on the blockchain. When predetermined conditions are met, these business contracts are automatically executed. Blockchain technology and smart contracts are known for their capability to address global supply chain issues by ensuring transparency and traceability of products, enabling secure coordination between partners, and aiding access to decentralised finance options.[26]

Non-Fungible Token (NFT):

NFTs can be used to record and verify the ownership of any unique digital or physical asset by maintaining a digital record on the blockchain.
The blockchain space consists of both fungible and Non-Fungible Tokens (NFTs). We can define 'fungibility' as the ability of an asset to be interchanged with a similar kind of asset. Therefore, only a unique asset can be considered as a NFT. When a NFT is created, it is immutably recorded on the blockchain which prevents others from modifying the ownership of the NFT. They are unique digital artifacts that are stored on the blockchain with each NFT being one-of-a-kind and can represent a variety of physical or digital assets.[27] In the context of the supply chain, NFTs can establish verifiable immutability and authenticity required as part of a supply chain, and provide additional features such as building unique and related identifiers.[28] NFTs are distinguishable, their ownership is trackable on an individual basis, and they provide the capability to associate metadata to each unique token for identification purposes.[29]

[23] Hofmann, E., & Rüsch, M. (2017). Industry 4.0 and the current status as well as future prospects on logistics. Computers in Industry, 89, 23–34. https://doi.org/10.1016/j.compind.2017.04.002
[24] https://hbr.org/2017/01/the-truth-about-blockchain
[25] Laneve, C., Coen, C. S., & Veschetti, A. (2019). On the Prediction of Smart Contracts' Behaviours. In From Software Engineering to Formal Methods and Tools, and Back (pp. 397–415). Springer International Publishing. https://doi.org/10.1007/978-3-030-30985-5_23
[26] Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L. (2019). Blockchain technology and its relationships to sustainable supply chain management. International Journal of Production Research, 57(7), 2117-2135
[27] D. Mouris and N. G. Tsoutsos, "NFTs For 3D Models: Sustaining Ownership In Industry 4.0," in IEEE Consumer Electronics Magazine, doi: 10.1109/MCE.2022.3164221
[28] Maleh, Y., Shojafar, M., Alazab, M., & Romdhani, I. (Eds.). (2020). Blockchain for cybersecurity and privacy: architectures, challenges, and applications. CRC Press
[29] Ibid

Digital twin:

Digital twin technology consists of creating virtual replicas of objects or processes that simulate the behaviour of their real counterparts.[30] In other words, they are digital versions updated in real time to create an exact replica of the real life version. An NFT can be a digital twin as can a supply chain.

A supply chain digital twin is a comprehensive simulation model of a real supply chain which uses real-time data to see information from the past, optimise the present and forecast the supply chain behaviours. The use of 3D and 4D mapping technology map the physical world and create digital twins for cities, retail spaces, store shelves and inventory. In the future, the applications will enable new interactions and transactions across businesses.[31] In the context of the supply chain, these applications have the potential to revolutionise how we currently track and manage supply chains and logistics by providing collaborative environments and data-driven decision making to create more robust business processes.

Artificial Intelligence (AI) and Machine Learning (ML):

AI can be defined as the "capability of a computer system to mimic human cognitive functions such as learning and problem-solving".[32]
ML is a subset and an application of AI that enables computer systems to continuously learn using the data models. Therefore, by leveraging AI/ML based technologies, we can build applications to forecast the supply and demand trends by analysing past and real-time data.

Autonomous (automated) vehicles, robotics and drones:

Fully automated supply chains with robots, drones and driverless vehicles are expected to be fully operationalised by 2025.[33] We believe that a new paradigm of transportation which is transport-as-a-service (TaaS) will be created through large-scale adoption of automated vehicles in Victoria.[34] This is also expected to provide better access to labour, markets and goods while creating new economies and services which are favourable to supply chains.

Internet of Things (IoT):

IoT can be defined as a network of interrelated physical objects and computing devices that are embedded with sensors and other software technologies to collect and share data. IoT plays a key role in converting day to day items and tools (machines, containers, trucks etc) we see in business processes, into smart and intelligent devices.
Supply chains are plagued by many issues such as effectiveness and efficiency of deliveries, continuous monitoring and close relationships between the partners.[35] The adoption of IoT allows greater transparency and visibility of data, including the monitoring of temperatures, positions, humidity, pressure, exposure to light, and broken seals[36], and can assist in reducing waste and costs.[37] In recent years, IoT applications have been widely used to locate, identify, monitor and track products and services in the supply chain.[38]

Cybersecurity:

Cybersecurity is the art of protecting networks, devices and data from unauthorised access or criminal use and the practice of ensuring confidentiality, integrity and availability of information.[39]

[30] Marmolejo-Saucedo, J. A. (2020). Design and development of digital twins: a case study in supply chains. Mobile Networks and Applications, 25(6), 2141-2160
[31] https://www2.deloitte.com/us/en/insights/topics/digital-transformation/web-3-0-technologies-in-business.html
[32] https://azure.microsoft.com/en-au/overview/artificial-intelligence-ai-vs-machine-learning/#introduction
[33] https://www.ey.com/en_au/supply-chain/how-covid-19-impacted-supply-chains-and-what-comes-next
[34] https://www.parliament.vic.gov.au/publications/research-papers/download/36-research-papers/13839-automated-vehicles
[35] Ben-Daya, M.; Hassini, E.; Bahroun, Z. Internet of things and supply chain management: A literature review. Int. J. Prod. Res. 2019, 57, 4719–4742
[36] Miorandi, D.; Sicari, S.; De Pellegrini, F.; Chlamtac, I. Internet of things: Vision, applications and research challenges. Ad Hoc Netw. 2012, 10, 1497–1516
[37] Mathaba, S.; Adigun, M.; Oladosu, J.; Oki, O. On the use of the Internet of Things and Web 2.0 in inventory management. J. Intell. Fuzzy Syst. 2017, 32, 3091–3101
[38] Lee, C.K.M.; Lv, Y.; Ng, K.K.H.; Ho, W.; Choy, K.L. Design and application of internet of things-based warehouse management system for smart logistics. Int. J. Prod. Res. 2018, 56, 2753–2768
[39] https://www.cisa.gov/uscert/ncas/tips/ST04-001

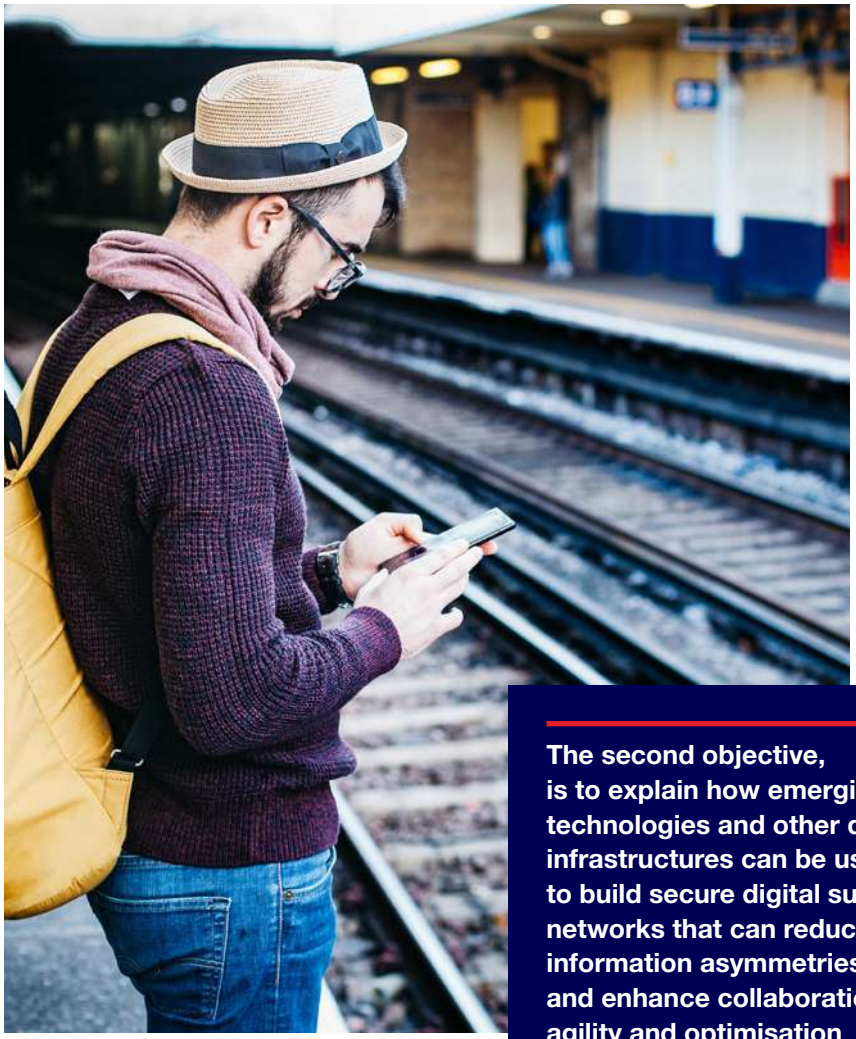
This report aims to explore two research objectives:

The first objective is proving a deeper understanding of the issues and challenges supply chains faced due to the twin shocks. This objective has been addressed by analysing the documents and other published materials from the years 2020 to 2022 for three specific supply chain domains.

The selected domains are:

1. **Food service and hospitality;**
2. **Construction; and**
3. **Renewable energy**

We examine the recent failures in these supply chain networks to identify mitigation strategies that will sustain resilience in the long term.



The second objective, is to explain how emerging technologies and other digital infrastructures can be used to build secure digital supply networks that can reduce the information asymmetries and enhance collaboration, agility and optimisation whilst embedding just and fairer practices into digital processes.

This report is being written at the very beginning of the post-pandemic era, while most of the supply chains around us are still struggling to recover from the challenges they faced during the pandemic, with the purpose of reflection to learn from the supply and demand shocks faced in the last two years and to build more resilient and just supply chains for the future of Melbourne. Our journey towards resilience began with technology adoption and innovation through the proposal of digitalisation of cities and supply chains. These challenges can be addressed for cities and the supply chains within them with the adoption of business process automation and the visualisation of data.

Finally, this report will contribute to strategic insights towards building resilient and just supply chains by highlighting research opportunities and policy recommendations for a digital CBD.

What caused the supply chain disruptions?

Supply chain vulnerabilities encountered during the COVID-19 pandemic can be divided into four areas:

1. **Workforce**
2. **Transportation**
3. **Information**
4. **Security**

Vulnerabilities from these areas caused some of the major supply chain issues that businesses experienced. Issues included inconsistent and sudden drops in workforce; unavailability of shipping containers and freight space in global supply chains; insufficient knowledge and control over the full supply chain network; and, security breaches and attacks in cyber supply chains.

In this section, we analyse these four supply chain vulnerabilities in detail to understand how they impacted supply chain resilience in Melbourne.

Workforce shortages

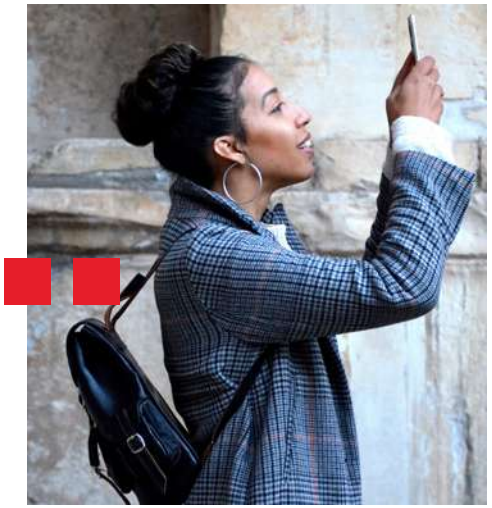
A skilled workforce is one of the key pillars of success for any organisation. The COVID-19 pandemic disrupted the employed workforce through sickness, isolation restrictions and work-from-home regulations, resulting in an inconsistent and sudden drop in the workforce.[40] During the third wave of COVID-19 with the highly contagious Omicron coronavirus variant,[41] the 'inconsistent and sudden drop in the workforce' turned into a massive labour supply issue. The issue was further aggravated with the failure of another supply chain of the Rapid Antigen Tests (RATs).

Australia's demand for RATs skyrocketed when employees within supply chain networks were battling with the Omicron coronavirus variant. RATs were not sufficiently available and caused massive staff shortages, consumer disappointment and other financial losses throughout supply chains.

Major supermarkets struggled to meet the required consumer demands of RATs and enforced buying limitations.[42] Individual organisations initiated direct procurement processes for RATs to minimise supply chain disruptions and staff shortages (eg Victorian Farmers Federation).[43] The shortage of essential goods such as RATs highlighted a lack of supply chain transparency and resilience, coupled with unsustainable just-in-time manufacturing leading to workforce shortages.[44]

This issue also affected business activities that are less automated and have highly labour intensive service-based supply chains. The hospitality industry which includes restaurants and bars was significantly impacted by population density requirements and staff shortages.[45] As a result, restaurants, bars and other retailers closed their doors to customers and determined opening hours based on staff availability.[46]

Employees of trucking and logistics industries as well as food and meat supply chains were disrupted, leading to empty shelves in the supermarkets while farmers were forced to throw away their produce.[47] The labour shortages amongst the logistics companies' workers and truck drivers, caused significant delivery delays, especially during the third wave of the pandemic. As communicated by the logistic operators, nearly half of their workers could not report to work on any given day.[48] In the next section, workforce shortage issues relating to the trucking and logistics industry that have also contributed to the transportation disruptions, are discussed.



[40] https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/rp/rp2021/COVID-19-Stat_ Snapshot
[41] https://www.health.gov.au/health-alerts/covid-19/case-numbers-and-statistics
[42] https://thewest.com.au/business/retail/coles-pulls-rats-from-online-sale-introduces-product-limits-in-wa-as-supply-chain-pressure-mounts-c-5294077
[43] https://www.northernbeachesreview.com.au/story/7587356/farm-groups-go-it-alone-and-order-own-supply-of-rats/?cs=9676
[44] Zhu, G., Chou, M. C., & Tsai, C. W. (2020). Lessons learned from the COVID-19 pandemic exposing the shortcomings of current supply chain operations: a long-term prescriptive offering. Sustainability, 12(14), 5858
[45] https://www.melbourne.vic.gov.au/about-council/committees-meetings/meeting-archive/MeetingAgendaItemAttachments/970/17286/MAR22%20FMC1%20AGENDA%20ITEM%206.3.pdf
[46] Ibid
[47] https://www.theguardian.com/australia-news/2022/jan/06/staff-shortages-batter-australian-economy-as-covid-surge-leaves-half-of-some-companies-employees-unable-to-work
[48] https://www.twu.com.au/trucking/covid-restrictions-impact-truckies/

Logistics: Transportation disruptions

The current global logistic crisis has pointed out many vulnerabilities in global container freight-based supply chains which usually operate as just-in-time. The just-in-time production is a method whereby the production lead time is greatly shortened by maintaining the conformity to changes by having "all processes produce the necessary parts at the necessary time and have on hand only the minimum stock necessary to hold the processes together".[49] Just-in-time' is a resource management strategy that moves resources just before it is needed for the next subsequent business operation. Under normal conditions, flow of materials, services, and resources throughout the nodes of supply chains would be close to frictionless. Supply chains can be highly optimised to increase overall efficiency by minimising the level of redundant resources at any node of these supply chain nodes.[50]

However, the current COVID-19 crisis has resulted in structural changes to the global economy that transforms modern just-in-time management into its just-in-case counterpart.[51]

During the pandemic, Australian importers and exporters were impacted by disrupted port operations, delayed shipments and rising costs affected by global supply chain disruptions. Timely distribution of products were interrupted due to increased border controls and trade-wars during the pandemic.[52] Both suppliers and consumers had to endure long wait times as well as product delays that disrupted supply chain operations. Businesses that imported seasonal products for Christmas and New Year were greatly impacted by the late arrival of shipments and some delays are reported to continue into early 2023.[53]

Global supply chains have also been affected by the shortage of empty shipping containers and the shortage of freight space on ships.[54] These shortages have led shipping companies to increase their charges significantly. For instance, 40-foot shipping container prices of freight rates have risen by over 300% in 2021.[55]

To gain a competitive advantage over other brands, companies have had to place their orders as early as possible to avoid product delays, which requires them to finalise their payments in advance. These issues have caused major operational and financial vulnerabilities in businesses that depend on global supply chains.

Research indicates that only ten percent of vessels arrived in their designated berth windows in 2020-21 and freight rates on key global trade routes are nearly seven times higher than they were a year ago.[56]

Even before the pandemic, Melbourne ports were identified as inefficient, performing below international best practices with some of these inefficiencies being infrastructural issues around capacity to support larger ships, lack of rail access to container ports, the shortage of space in parking these containers, the enormous slack in their container berths, terminal area and labour inputs.[57]

[49] Sugimori, Y., Kusunoki, K., Cho, F., & UCHIKAWA, S. (1977). Toyota production system and kanban system materialization of just-in-time and respect-for-human system. The international journal of production research, 15(6), 553-564

[50] Garnett (n 14)

[51] Brakman, S., Garretsen, H., & van Witteloostuijn, A. (2020). The turn from just-in-time to just-in-case globalization in and after times of COVID-19: An essay on the risk re-appraisal of borders and buffers. Social Sciences & Humanities Open, 2(1), 100034

[52] https://www.aph.gov.au/Parliamentary_Business/Committees/Joint/Foreign_Affairs_Defence_and_Trade/FADTandglobalpandemic/Report/section?id=committees%2Freportjnt%2F024552%2F73973

[53] https://www.news.com.au/finance/money/costs/global-shipping-crisis-to-affect-australian-christmas-presents-and-beyond/news-story/782509c6b1a4901e7ead0a126fade10a

[54] Fonseca (n 2)

[55] https://www.drewry.co.uk/supply-chain-advisors/supply-chain-expertise/world-container-index-assessed-by-drewry#:~:text=Our%20detailed%20assessment%20for%20Thursday%2C%207%20April%202022&text=The%20average%20composite%20index%20of,of%20%243%2C208%20per%2040ft%20container

[56] https://www.accc.gov.au/publications/container-stevedoring-monitoring-report/container-stevedoring-monitoring-report-2020-21

[57] The ports of Melbourne, Rotterdam, Yokohama and Osaka are found to be the most inefficient ports in the sample, based on constant and variable returns to scale assumptions, mainly due to the enormous slack in their container berths, terminal area and labor inputs

Information asymmetry: Insufficient knowledge and control across the full supply chain network

One of the key challenges in supply chains is to align the supply chain decisions of separate entities with independent objectives.[58] Information asymmetry among supply chain partners is one of the hidden factors that contributes to disruptions in supply chain planning and forecasting activities. Information asymmetry is the condition when information is not equally distributed and communicated usually created by selective disclosure resulting in business imbalances.[59]

Information asymmetry refers to the scenario in which some information (eg cost information, demand information, supply information, etc) is private and not public to all supply chain members resulting in information asymmetry existing within the supply chain.[60] Information updating or sharing can overcome or mitigate the negative effects of information asymmetry.

During the COVID -19 crisis, we have experienced information asymmetry through unprecedented demand inconsistencies, product supply and labour shortages, inventory management and other product-related issues.[61] Businesses usually pay attention only to the steps of the supply chain that they facilitate or directly depend on. For instance, businesses regularly talk to direct suppliers and direct consumers and may not build relationships with a direct supplier's supplier or with a customer's customer. This is the reason that most businesses do not have a holistic overview of the supply chain networks they belong to.

For instance, if a supply chain depends too much on a single supplier for a crucial component of a production process, the failures of this supplier can make the entire supply chain vulnerable.[62] To avoid these failures, greater information symmetry and transparency should be strived for by all members of a supply chain.

Global supply chains span across countries, supporting the information and product flow across national borders. In global supply chains, businesses have the advantage of manufacturing the products in countries where the costs of labour and resources are the lowest and then sell in other countries where demand for the products are high.[63] Global supply chains are also able to increase their profits by moving production processes to developing countries to reduce production costs, shipping the manufactured items to developed countries and selling them for premium prices.[64] However, in the context of global supply chains, transparency and visibility over the supply chain processes can be limited.[65]

Due to legal constraints, buyers might not have complete control over the supply chain activities which makes it difficult to gather information relating to sustainability or the quality of the raw materials used in the production process or the work practices.[66]

Information asymmetry does not only make supply chains vulnerable but also contributes to unjust and unfair work practices by creating power imbalances within supply chains. It further enhances the information asymmetry discrepancies through the supply chain network. One of the best examples to illustrate this point is the poor work practices of the world's biggest electronics contract manufacturer Foxconn to meet the high demand of the tech giant Apple.[67]

The resilience in operational activities is a major factor that ensures the stability of these powerful players in business, and it allows them to control the entire supply chain. In order to secure the business relationships with powerful customers and honour the contractual obligations, the suppliers also have to stay resilient towards the challenges they encounter in their day-to-day operations.[68]

[58] Vosooghidizaji, M., Taghipour, A., & Canel-Depitre, B. (2020). Supply chain coordination under information asymmetry: a review. International Journal of Production Research, 58(6), 1805-1834
[59] Lambert, R. A., Leuz, C., & Verrecchia, R. E. (2012). Information Asymmetry, Information Precision, and the Cost of Capital. Review of Finance, 16(1), 1–29. https://doi.org/10.1093/rof/rfr014
[60] Shen, B., Choi, T.-M., & Minner, S. (2019). A review on supply chain contracting with information considerations: information updating and information asymmetry. International Journal of Production Research, 57(15-16), 4898–4936 https://doi.org/10.1080/00207543.2018.1467062
[61] https://www.accenture.com/au-en/insights/consulting/coronavirus-supply-chain-disruption
[62] Biswas, I., Adhikari, A., & Biswas, B. (2021). Channel coordination of a risk-averse supply chain: a mean–variance approach. Decision (Calcutta), 47(4), 415–429. https://doi.org/10.1007/s40622-020-00267-1
[63] Fonseca (n 2)
[64] Handfield, R., Sun, H., & Rothenberg, L. (2020). Assessing supply chain risk for apparel production in low cost countries using newsfeed analysis. Supply Chain Management, 25(6), 803–821. https://doi.org/10.1108/SCM-11-2019-0423
[65] Fonseca (n 2)
[66] Handfield (n 64)
[67] https://www.nationaltribune.com.au/apple-and-foxconn-how-can-suppliers-fight-tech-giant/
[68] Christopher (n 15)

Security: Increased number of security breaches and attacks in digital supply chains

Cybersecurity as it relates to supply chains is defined as a holistic, systems approach that draws upon technology, procedures, and people to protect network, systems, devices and digital assets from damage, attack, or unauthorised access due to agents and/or organisations targeting and exploiting (directly or indirectly) weaknesses in the supply chain network.[69] The increased number of security breaches and attacks in digital supply chains makes it necessary to give cybersecurity its due pivotal position in global supply chains.[70] In order to protect the supply chain networks, it is not sufficient to only look at the operational resilience within supply chains, but also have a focus on achieving cyber resilience. Cyber resilience is defined as the capacity of a system to recover quickly from the difficulties and problems created by a cyberattack.[71] Cyber resilience provides a more robust integration of cybersecurity into the enterprise's risk management system.[72]

In 2021, the number of security breaches and attacks on the software supply chain tripled.[73] Attackers focus on open-source vulnerabilities; code integrity issues; and exploiting the software supply chain process to distribute malware or backdoors.[74] Supply chains are attractive for malicious users as they can get access to the systems by focusing on attacking the weakest link in the chain that does not have the strongest cyber defences in place. If a malicious user exploits even a single vulnerability within one of the entities of the supply chain, it can get access and compromise the entire supply chain network including other entities. According to research, more than 50% of the security breaches in companies are caused due to vulnerabilities of third-party vendors.[75] Therefore, to build a cyber-resilient supply chain, all the nodes should be protected from attackers.

Due to the stay at home and work-from-home mandates during the COVID -19 pandemic, most workers were forced to work from home. These hybrid work conditions widened the attack surface of companies for cybercriminals. By exploiting less secure home network connections and remote working solutions, attackers were able to access the internal systems of companies. For instance, Australian logistic company Toll, was hit by two types of ransomware attacks in 2020.[76] One of the attacks was a new variant of Nefilim ransomware targeting vulnerabilities in Remote Desktop Protocols.[77] Consumers were also an easy target for cybercriminals as less tech-savvy buyers started to shop online. Cybercriminals usually aim to steal money or personal details from online shoppers.[78] One of the techniques used to steal payment details is through 'formjacking' where hackers insert a malicious code into the payment page of the targeted website.

Formjacking in cyberspace is a two-stage attack where first a malicious code is implemented and then credit card data is captured in real time, similar to virtual automated teller machine skimming attacks, where a malicious code is injected by cyber criminals in a website to steal customer card details.[79] These attackers also can employ 'online skimming' tools to steal personal and financial data from e-commerce websites.[80]

[69] Melnyk, S. A., Schoenherr, T., Speier-Pero, C., Peters, C., Chang, J. F., & Friday, D. (2022). New challenges in supply chain management: cybersecurity across the supply chain. International Journal of Production Research, 60(1), 162–183. https://doi.org/10.1080/00207543.2021.1984606

[70] Ibid

[71] Sawik, T. (2020). "A Linear Model for Optimal Cybersecurity Investment in Industry 4.0 Supply Chains." International Journal of Production Research: 1–18

[72] Melnyk (n 69)

[73] Ibid

[74] Abdelrahman, A. M., Rodrigues, J. J. P. C., Mahmoud, M. M. E., Saleem, K., Das, A. K., Korotaev, V., & Kozlov, S. A. (2021). Software-defined networking security for private data center networks and clouds: Vulnerabilities, attacks, countermeasures, and solutions. International Journal of Communication Systems, 34(4). https://doi.org/10.1002/dac.4706

[75] Melnyk (n 69)

[76] https://www.afr.com/technology/hacked-again-toll-group-systems-hit-by-fresh-ransomware-attack-20200505-p54q19

[77] https://www.itnews.com.au/news/toll-group-suffers-second-ransomware-attack-this-year-547757

[78] https://www.cyber.gov.au/online-shopping

[79] Dharmavaram, V. G. (2021). Formjacking attack: Are we safe? Journal of Financial Crime, 28(2), 607–612. https://doi.org/10.1108/JFC-07-2020-0138

[80] Leukfeldt, E. ., Stol, W. P., & Kleemans, E. . (2017). A typology of cybercriminal networks: from low-tech all-rounders to high-tech specialists. Crime, Law, and Social Change, 67(1), 21–37. https://doi.org/10.1007/s10611-016-9662-2

Other than free shipping and free returns offered through e-commerce websites, many retailers have enabled the option to request express delivery and same day delivery for an extra fee which has put pressure on delivery and logistic operations. To address the sudden surge in their services, logistic companies are currently looking into adopting resilient supply chains by exploring new technologies to automate the manual processes using AI-driven chatbots, autonomous trucks and forklifts, robots and IoT devices.[81]

With these technologies, the information systems of logistic companies are becoming more vulnerable to cyber security threats such as phishing and ransomware.[82] During the last few years, the number of IoT devices in use has increased in the logistics sector. The global IoT in the logistics market is projected to increase by a compound annual growth rate of 13.2% during the forecast period (2020-2030) with the IoT market predicted to rise to $100,984.5 million by 2030.[83]

As the number of IoT devices in use increases, so do cyber threats. This is because the majority of traffic generated from IoT devices are unencrypted and do not possess built-in security features, so are extremely vulnerable to security threats.

As we can see, there are many types of supply chain attacks. Criminals can target attacks to both physical and virtual property of companies. Therefore, the in-house hardware and cloud-based software infrastructure, as well as user identities and credentials, all need to be protected from malicious attacks. Common supply chain security issues are mainly around inventory theft or shrinkage (inventory losses due to other errors and damages), counterfeit goods and tampering with systems and devices which can happen in the various supply chain stages including in storage as well as in transit.[84]

Consequently, there needs to be secure mechanisms in place to monitor items throughout the supply chain process.

Global supply chains also have to protect themselves from counterfeit products and criminals manipulating the physical and digital Infrastructure to smuggle counterfeit products.[85]

Supply chains with postponed demand and shutdown capacity during the COVID-19 pandemic are particularly prone to after-shocks such as “disruption tails”. The effect of residue from a disruption period, such as backlog and delayed orders, can appear in the post-disruption / recovery period and may influence supply chain operations and performance even after the disruption recovery.

For example, “a highly excessive inventory and destabilisation of inventory dynamics can be observed after a capacity disruption recovery as a consequence of backlog orders if an inventory control policy is not adapted accordingly.”[86] Disruption tails are the postponed effects of demand–supply mismatches during a disruption.

These disruption tails have the potential to influence supply chain operations and performance even after the disruption recovery.[87]

In this section, we have discussed how workforce shortages, transportation disruptions, and information asymmetry along with the shift to working from home, disrupted the resilience of supply chains. All of these conditions have created new security threats that need to be managed.

Next, we look at three diverse supply chain case studies that illustrate these challenges in practice and discuss mitigation strategies for any future shocks.

[81] Frederico, G. F. (2021). Towards a Supply Chain 4.0 on the post-COVID-19 pandemic: a conceptual and strategic discussion for more resilient supply chains. Rajagiri Management Journal, 15(2), 94–104. https://doi.org/10.1108/RAMJ-08-2020-0047

[82] (n 76)

[83] https://www.businesswire.com/news/home/20201127005295/en/100-Billion-IoT-in-Logistics-Market---Global-Industry-Analysis-and-Growth-Forecast-to-2030---ResearchAndMarkets.com

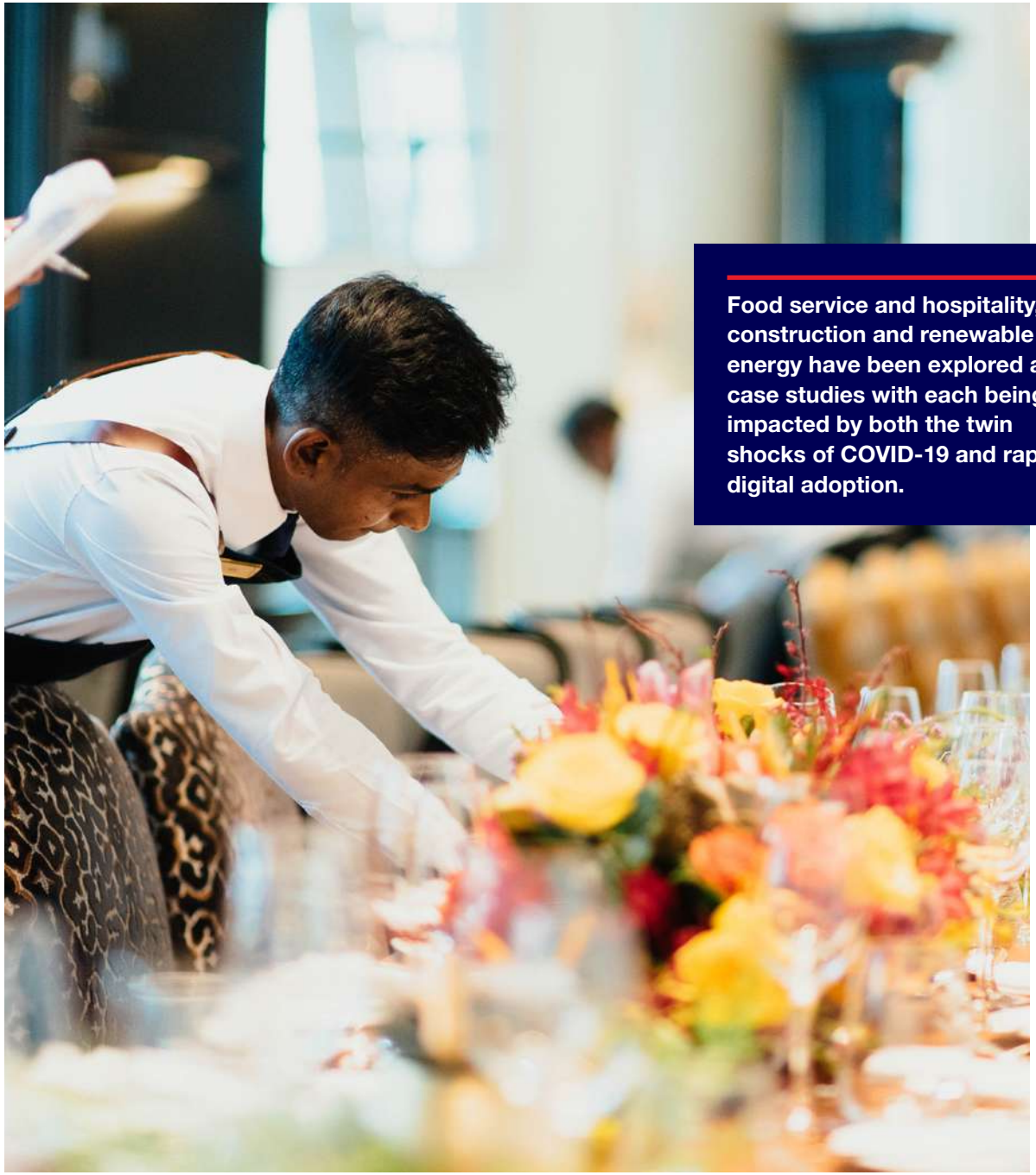
[84] Marucheck, A., Greis, N., Mena, C., & Cai, L. (2011). Product safety and security in the global supply chain: Issues, challenges and research opportunities. Journal of Operations Management, 29(7), 707–720. https://doi.org/10.1016/j.jom.2011.06.007

[85] Ghadge, A., Duck, A., Er, M., & Caldwell, N. (2021). Deceptive counterfeit risk in global supply chains. Supply Chain Forum, 22(2), 87–99. https://doi.org/10.1080/16258312.2021.1908844

[86] Ivanov, D. (2021). Exiting the COVID-19 pandemic: after-shock risks and avoidance of disruption tails in supply chains. Annals of Operations Research, 1–18

[87] Ibid

Case studies



Food service and hospitality, construction and renewable energy have been explored as case studies with each being impacted by both the twin shocks of COVID-19 and rapid digital adoption.

Case studies

Overview

Food service and hospitality was selected as a case study given the number of businesses located in Melbourne's CBD that have been significantly impacted by COVID-19 and the various lockdowns experienced throughout 2020 and 2021.
The construction industry was chosen based on the investment in buildings and infrastructure in Melbourne and its greater regions. Finally, renewable energy was selected as energy has been identified as one of the critical infrastructures in Victoria.[88]

As part of each case study, some background information, and a discussion of some of the challenges experienced through the COVID-19 pandemic are presented. This is followed by a discussion on potential mitigation strategies to help each industry recover, as well as prepare for future shocks. Information for both sections come from a range of both academic publications, as well as industry-based publications.

[88] https://www.emv.vic.gov.au/victorias-critical-infrastructure-all-sectors-resilience-report-2021

Case study 1: Food service and hospitality

Background and the challenges

The food service and hospitality industry has been presented with significant challenges since COVID-19 first arrived in Victoria in early 2020.

Government guidelines (both federal and state) consisted of community lockdowns, social distancing, stay-at-home orders, travel and mobility restrictions. This resulted in temporary and in some cases permanent closures of many hospitality businesses.[89]

Restaurants, hotels, casinos and sporting venues were empty for lengthy periods of time as the state moved in and out of lockdown throughout 2020 and 2021 to contain the spread of COVID-19. In terms of cafes and restaurants, rather than the traditional onsite service, there was an explosive increase in demand for online orders, takeaway and drive-thru services, as well as an increase in demand for various meal replacements and meal-kits.[90] As a result, the catering and food delivery market now faces significant competition and has become a large industry in itself due to the introduction of online food delivery services.[91] Food delivery applications such as Menulog, Deliveroo, and Uber Eats have emerged as a new service within the economy.[92]

The logistics of food delivery was a challenge prior to COVID-19 however the growth in this area has now amplified its importance. Last-mile delivery (also known as last-mile logistics or final mile delivery) has become more relevant in recent years which has an emphasis on environmentally conscious and sustainable logistics.[93] Last-mile delivery is critical to the efficiency of supply chain and logistics management,[94] yet has been impacted by the limited movement of transport systems during COVID-19. In the context of this report, food delivery from 'farm to fork' (F2FO) has also gained interest and momentum. F2FO is a term commonly used to describe food supply chains that are focused on the delivery of local and regional agricultural products within a limited geographical area.[95] Agriculture, and more specifically, urban agriculture has an important role to play in food chain sustainability and security.[96]

As we saw throughout 2020 and 2021, the availability of perishable food items such as fresh fruits, vegetables and meat was constricted due to labour shortages. Supermarkets had to ensure that purchase limits were placed on available products to avoid unjust product distributions caused by 'panic buying'. The Australian Competition and Consumer Commission (ACCC) also played a critical role in enabling supermarket operators to immediately coordinate their resources to ensure consumers had reliable and fair access to groceries during the COVID-19 pandemic, especially those who were vulnerable or lived in rural and remote areas.[97]

[89] Bartik, A. W., Bertrand, M., Cullen, Z. B., Glaeser, E. L., Luca, M., & Stanton, C. T. (2020). How are small businesses adjusting to COVID-19? Early evidence from a survey (No. w26989). National Bureau of Economic Research

[90] Lee, S., & Ham, S. (2021). Food service industry in the era of COVID-19: trends and research implications. Nutrition research and practice, 15(Suppl 1), S22–S31. https://doi.org/10.4162/nrp.2021.15.S1.S22

[91] Lin, Y., Marjerison, R. K., Choi, J., & Chae, C. (2022). Supply Chain Sustainability during COVID-19: Last Mile Food Delivery in China. Sustainability, 14(3), 1484

[92] Ibid

[93] De, A.; Aditjandra, P.; Pang, G.; Hubbard, C.; Gorton, M.; Thakur, M.; Samoggia, A. Environmentally Conscious Transportation and Logistics Modelling for Agri-Food Supply Chains; Newcastle University: Newcastle, UK, 2019

[94] Ewedairo, K., Chhetri, P., & Jie, F. (2018). Estimating transportation network impedance to last-mile delivery: A Case Study of Maribyrnong City in Melbourne. The International Journal of Logistics Management.

[95] Alsetoohy, O.; Ayoun, B.; Abou-Kamar, M. COVID-19 Pandemic Is a Wake-Up Call for Sustainable Local Food Supply Chains: Evidence from Green Restaurants in the USA. Sustainability 2021, 13, 9234

[96] Lal, R. Home Gardening and Urban Agriculture for Advancing Food and Nutritional Security in Response to the COVID-19 Pandemic. Food Secur. 2020, 12, 871–876

[97] https://www.accc.gov.au/media-release/supermarkets-to-work-together-to-ensure-grocery-supply

Finally, within the broader state of Victoria, significant disruptions emerged from workforce outbreaks of COVID-19 in the meat processing sector and in fruit and vegetable production.[98] The labour shortage brought on by the Omicron Wave significantly impacted supply chains across all industries. Supermarkets, cafes, restaurants and hospitality providers were adversely affected due to the supply chain crisis. Some fast-food restaurants even considered moving from trucks to air freight in an attempt to avoid food supply chain disruptions.[99]

While the major supermarket supply chains were struggling with a significant supply-chain crisis and staff shortages due to the various waves of COVID-19, the public were informed that fresh produce markets did not encounter any supply-chain related issues.[100] One of the main reasons for this is how supply chains are structured and managed in the fresh produce wholesale markets compared to the major supermarkets.

The fresh produce markets do not rely on specific individuals or entities, which leads to a more resilient supply chain.

The governance and control of the supermarket supply chains are centralised, but fresh produce markets occupy a more decentralised and distributed supply-chain structure-a collection of small supply chains that collaboratively work towards the same goal, which is fulfilling the food demands of consumers. Therefore, even in situations where a specific supply chain has failed to contribute, it will not have a significant impact on the overall supply chain network.

As presented by the Organisation for Economic Co-operation and Development (OECD), supply chain actors have been able to reorganise themselves with rapid agility to ensure the continued availability of food.[101] However, bottlenecks and challenges remain, and some new disruptions may emerge as we work through the COVID-19 pandemic and move into a 'new normal'.

98 Hobbs, J. E. (2021). Food supply chain resilience and the COVID-19 pandemic: What have we learned?. Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie, 69(2), 189-196

99 https://www.afr.com/companies/retail/subway-considers-air-freight-as-food-supply-crisis-worsens-20220112-p59nng

100 https://www.theguardian.com/business/2022/jan/14/how-fresh-food-markets-are-avoiding-australias-crippling-supply-chain-crisis

101 https://read.oecd-ilibrary.org/view/?ref=134_134305-ybqvdf0kg9&title=Food-Supply-Chains-and-COVID-19-Impacts-and-policy-lessons

Case study 1: Food service and hospitality

Mitigation strategies for future shocks

Despite the challenges presented to the food service and hospitality supply chain throughout 2020 and 2021, there have been many lessons, strategies and approaches to working in the new normal, post-COVID-19. Whilst technology may appear to be the overall solution to these challenges, there are a number of provisos that need to be made. Fragmented technologies cost companies time and resources.[102] Having disparate systems can create friction and unnecessary costs. Multiple-sourced data means room for error.[103]
As companies attempt to consolidate these fragmented technologies and strive for consistency and standards both inter- and intra-organisationally, this process often breaks down across supply chains where the different links in the chain are using different systems.

That being said, having the right technology in place can provide resiliency, integration, transparency and efficiency. The technologies adopted need to be multi-pronged and be able to coordinate data, automate data and be able to execute actions in real-time. Data needs to be unified from various silos and systems into one ecosystem where the data flows freely between companies and systems. Doing this results in more informed decision-making via accurate real-time data, which a coordinated supply chain can provide.

[102] https://www.fooddive.com/news/why-the-food-supply-chain-needs-a-technology-makeover/582638/
[103] Ibid

Also gaining popularity is the use of digital twins aligning with supply chain operations. A supply chain digital twin is a detailed simulation model of an actual supply chain and uses real-time data and snapshots to forecast supply chain dynamics.[104] Organisations are now getting significant benefits from digital twin technology that assists in mapping and analysing details related to operations performance, product and service innovation, and shorter on-time delivery.[105] Much of these strategies rely on the transparency of data within the organisation and across the end-to-end supply chain. This transparency enables better forecasting with greater accuracy, as well as the ability to embrace the agile supply chain.

Leveraging the distributed and decentralised architecture of the blockchain network, all entities along the food service and hospitality industry, including the farmers, distributors and retailers, can record all necessary information related to the production, distribution and storage of food products. By utilising the blockchain, all key stakeholders have end-to-end visibility throughout the supply chain and can also use this to easily identify any potential issues and fraudulent activities along the food service and hospitality supply chain. The information stored on the blockchain is beneficial to ensure the food safety and certification processes of relevant authorities as well. By analysing the recorded data, these authorities can easily identify the distributed portion of food with safety concerns and then take required actions.

Australia already has operationalised blockchain-based smart tracking software solutions integrated with data captured from IoT devices and other data sources from various supply chain partners to enhance the food quality in both local and global food supply chains.[106] These blockchain-based solutions have the potential to create trustworthy relationships with multiple entities and individuals in the supply chain network by securely storing all their data while respecting the data integrity of all the partners. By leveraging the smart contracts which are business logics written as computer code and deployed on the blockchain network, the contractual and payment agreements can be easily automated. These blockchain-based solutions ensure that all entities get their payments immediately while other partners also save time and money.

Consumers are seeking more information about how their food is produced. Cafes, restaurants and supermarkets also want assurance from farmers that foods are produced to their standards. For example, how can the farmers prove to their consumers the organic food they are producing is truly ‘organic’? How can consumers ensure the authenticity and safety of the food they are eating? A packet of food can be produced, packaged and distributed by separate organisations based in multiple countries. There can be multiple stakeholders including the government that seek further information on food from ‘farm to fork’. Therefore, farmers should be able not to just capture the information related to the agricultural process, but also securely store them for both data provenance and data analytics purposes.

[104] Marmolejo-Saucedo (n 31)
[105] Mittal, S.; Tolk, A.; Pyles, A.; Van Balen, N.; Bergollo, K. Digital Twin Modeling, Co-Simulation and Cyber Use-Case Inclusion Methodology for IOT Systems. In Proceedings of the 2019 Winter Simulation Conference (WSC), National Harbor, MD, USA, 8–11 December 2019; IEEE: New York, NY, USA, 2019; pp. 2653–2664
[106] https://www.trustprovenance.com/

Further, with labour shortages reported due to the COVID-19 pandemic, there is a substantial need for innovative autonomous devices, which could be developed and deployed along with human workers to reduce the over-reliance on manual labour the 'farm to fork' supply chain. Autonomous vehicles can eradicate dull and dangerous tasks and create skilled job opportunities in the food service and hospitality industry. We are already seeing restaurants and cafes in Melbourne's CBD making use of robot waiters. Dodee Paidang Thai are making use of robot waiters called 'Bellabots' which take meals straight from the kitchen to diners.[107] Superhiro Japanese Restaurant and Bar have been trialling the use of robot waiters since August 2021.[108] DooBoo, a Korean restaurant, is also experimenting with robot waiters.

Strategies to mitigate risk and to improve delivery lead-time to food service and hospitality businesses, particularly in the CBD, could include regulatory measures, techno-institutional reforms, infrastructural improvement and operational alignment. Last-mile corridor strategies could be implemented along main arterial networks through a linear freight route to improve last-mile efficiency between key business hubs.[109] The use of a dedicated delivery corridor including time-window-based loading/unloading would help reduce the environmental footprint of last-mile delivery, and ease traffic bottlenecks and user conflicts between last-mile delivery trucks and other road users. Furthermore, adopting a distribution network strategy that holistically integrates people, facilities and transportation infrastructure as a single unified logistics system, all leads to last-mile delivery efficiency.[110]

However, with many of these mitigation strategies, the use of the right technology is important, and with the use of any technology, ensuring cyber security end-to-end across supply chains is even more vital. The questions that need to be addressed here include:[111]

1. **What security measures are used to protect any forms of enduring access?**
2. **What is the extent of access that products and services will have to systems and data?**
3. **Does the business require enduring access to their products, or their customers' systems or data?**
4. **Will data be stored anywhere other than within Australia?**
5. **Is mandatory cyber security incident reporting included in contracts?**

[107] https://www.9news.com.au/national/melbourne-thai-restaurant-dodee-paidang-using-robots-to-combat-shortages-in-hospitality-industry/9ab449ad-879f-4d3e-ab12-dcfea79ae5f9
[108] https://www.dailymail.co.uk/femail/article-10409627/Melbourne-restaurant-Superhiro-delights-diners-robot-waiters-serve-food.html
[109] Srai, J.S. and Harrington, T.S. (2014), "E-commerce-driven last-mile logistics networks", in Srai, J.S. and Christodoulou, P. (Eds), Capturing Value from Global Networks: Strategic Approaches to Designing International Production, Supply and Service Operations, University of Cambridge, Institute for Manufacturing, Cambridge, pp. 67-71
[110] Ewedairo (n 94)
[111] https://www.cyber.gov.au/acsc/view-all-content/publications/identifying-cyber-supply-chain-risks

Case study 2: Construction

Background and challenges

The construction industry is focused on the construction, demolition, renovation and maintenance or repair of building and infrastructure. It covers a wide range of services from planning and surveying to structural construction to finishing services such as painting and decorating.[112]

Even though Victoria was placed in six State-mandated lockdowns throughout 2020 and 2021, more than $15 billion of work was carried out in Victoria between July and September 2021.[113] This was an increase by almost 6% from the previous quarter and was considerably stronger compared to other states and territories. Total building and construction work fell in New South Wales (-8.1%), Western Australia (-3.2%) and the Australian Capital Territory (-15.5%) while all other states and territories experienced growth.[114]

Despite the growth and investment in the Victorian construction industry, the COVID-19 pandemic has still had an adverse effect. Disruptions to the supply chain for construction equipment, building materials and skilled labour have delayed progress on projects and added to construction costs.[115] In particular, supply chain disruptions have affected imported component parts, building materials and construction equipment sourced from regions most severely affected by the pandemic, including China, the European Union and the United States.[116]

Vrijhoef and Koskela[117] presented three characteristics relating to the role of the supply chain in construction:

The construction supply chain is a typical make-to-order supply chain, with every project creating a new product or prototype. There is little repetition, with minor exceptions.

Despite being a typical make-to-order supply chain, it is a temporary supply chain producing one-off construction projects. As a result, the construction supply chain is typified by instability, fragmentation and especially by the separation between the design and the construction of the built object.

Finally, the construction supply chain is a converging supply chain directing all materials to a construction site where the object is assembled from incoming materials.

[112] https://business.gov.au/planning/industry-information/building-and-construction-industry
[113] https://www.mbav.com.au/news-information/media-release/victoria%E2%80%99s-booming-building-and-construction-industry-drives-nation?policy
[114] Ibid
[115] https://www.ibisworld.com/au/industry/construction/306/
[116] Ibid
[117] Vrijhoef, R., & Koskela, L. (2000). The four roles of supply chain management in construction. European journal of purchasing & supply management, 6(3-4), 169-178

The typical supply chain for any given construction project could include architects and engineers, main contractors, speciality subcontractors and material suppliers that come together one time to build a project for a specific owner.[118] Further, there is minimum coordination and collaboration between these different entities, links or stakeholders of the construction supply chain during the life cycle of the project. Construction supply chain processes and the interdependencies between stakeholders to ensure successful project execution is considerably complex.[119] Information is generated by these various stakeholders and can be both abstract and/or detailed, which contributes to the fragmentation highlighted above. The organisation and sourcing of materials is also becoming increasingly complex across the global construction industry[120] due to the global sourcing of materials.

This eventually results in a lack of communication and implementation and leads to significant negative performance impacts – low productivity, cost and time overruns, change orders, inadequate design specifications, liability claims, and generally, conflicts and disputes – which directly impact the customer by increasing project completion time and cost.[121]

Given the instability, fragmentation and multiple temporary links, the technology associated with the construction supply chain is of significant importance. For example, the use of information technology (IT) is suggested to achieve better logistics processes and avoid delays.[122]

Additionally, the use of technology enables the sharing of up-to-date information between stakeholders, which leads to a reduction of errors and time delays and consequently facilitates more effective and efficient productivity and ultimately improves collaboration and teamwork. Technology adoption creates more efficient information-related activities such as the creation, retrieval and delivery of information as well as effective communication, which assists with increasing productivity.

Secondary effects of utilising technology includes efficient material-handling in information processing particularly where it contributes to inventory reduction and efficiencies in rebuilding with accurate design information.[123] Conversely, technology used across the construction supply chain generates an enormous amount of data, leading to information overload. Such use of technology involves significant information management load in security, filtering, consistency checking, data cleaning, storing, knowledge discovery, and knowledge integration.[124]

Finally, the transport and logistics of construction materials and their delivery within Melbourne's CBD poses another challenge for the construction supply chain. The industry does not elect where it conducts its activities, and therefore must move where the work is.[125] As such, the transportation cost of materials represents a large percentage of the cost profile of the construction industry. Ying, Tooky and Roberti[126] identified four contributions to inefficiency as part of logistics and transportation in the construction supply chain:

1. **logistics efficiency varies in accordance with materials supply chain characteristics;**
2. **suboptimal planning of material delivery and unloading;**
3. **delivery construction materials during peak hours, adding to congestion; and**
4. **inadequacy of material delivery and construction and demolition waste integration.**

[118] Behera, P., Mohanty, R. P., & Prakash, A. (2015). Understanding construction supply chain management. Production Planning & Control, 26(16), 1332-1350
[119] Chen, Q., Hall, D. M., Adey, B. T., & Haas, C. T. (2020). Identifying enablers for coordination across construction supply chain processes: a systematic literature review. Engineering, Construction and Architectural Management
[120] O'Brien, W. J., Formoso, C. T., Ruben, V., & London, K. (2008). Construction supply chain management handbook. CRC press
[121] Ibid
[122] Omar, B., & Ballal, T. (2009). Intelligent wireless web services: context-aware computing in construction-logistics supply chain. ITcon, 14(Specia), 289-308
[123] Zou, P. X., & Seo, Y. (2006). Effective applications of e-commerce technologies in construction supply chain: current practice and future improvement. Journal of Information Technology in Construction (ITcon), 11(10), 127-147
[124] Badii A. and Sharif A. (2003). Information management and knowledge integration for enterprise innovation, Journal of Logistics Information Management, Vol. 16, No. 2, 145-155
[125] Ying, F., Tookey, J., & Roberti, J. (2014). Addressing effective construction logistics through the lens of vehicle movements. Engineering, construction and architectural management
[126] Ibid

Case study 2: Construction

Mitigation strategies for future shocks

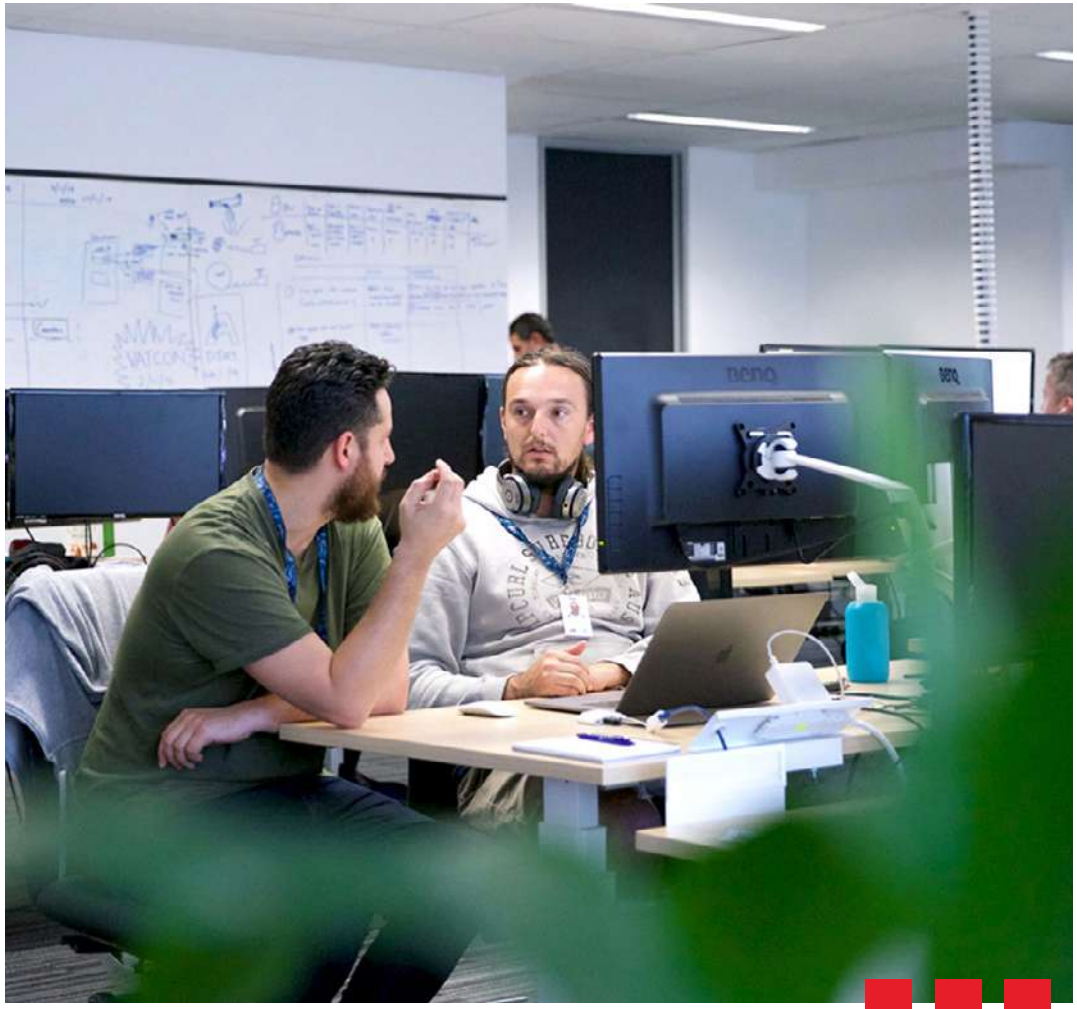
Again, despite the various impacts of COVID-19 in the construction supply chain, the Victorian construction industry led the nation in activity with 5.8% growth in the third quarter of 2021.[127]

However, there is no room for complacency in the construction supply chain and Victoria should be leveraging its placing of significant growth and investment in various construction projects such as the Metro Tunnel, Queen Victoria Market Precinct Renewal Program, the Major Roads Projects Victora, and the Melbourne Airport Rail, to name just a few. Melbourne is projected to be Australia's largest city as early as 2030[128] and currently employs almost 240,000 people and contributes $21.6 billion to the Victorian economy. Challenges for 2022 have already arisen and includes one of the construction giants (Probuild) going into administration in February 2022.[129]

As a result, $5 billion worth of major building projects stalled. Adding to this is the fact that Melbourne (and Sydney and Brisbane) are among the most expensive cities to build in worldwide[130] resulting in a more significant portion of costs being absorbed by the supply chain.

As with any supply chain, the greater the integration, the greater the efficiency and effectiveness of that supply chain. Effective construction supply chain management requires an approach developed on the circumstances of the firm rather than just collaboration and integration.[131] Knowledge management generally deals with the systematic and organised attempt to use knowledge within an organisation to transform its ability to store and use it to improve performance.[132] Specifically, integrated knowledge management mechanisms can help improve the organisational performance and reduce knowledge asymmetry among supply chain partners.[133]

[127] https://www.theage.com.au/national/victoria/victorian-construction-leads-the-nation-through-lockdowns-20211124-p59bth.html
[128] https://liveinmelbourne.vic.gov.au/connect/victorian-industries/transport-defence-and-construction
[129] https://www.theage.com.au/national/victoria/more-than-5b-in-melbourne-construction-projects-to-sit-empty-as-probuild-folds-20220224-p59zdr.html
[130] https://www.arcadis.com/en/knowledge-hub/perspectives/global/international-construction-costs
[131] Khalfan, M. M., Kashyap, M., Li, X., & Abbott, C. (2010). Knowledge management in construction supply chain integration. International Journal of Networking and Virtual Organisations, 7(2-3), 207-221
[132] Ibid
[133] Ibid



An extension of knowledge management, with a particular focus on technology, is the adoption of Building Information Modelling (BIM) software. BIM can be defined as a virtual process that includes all aspects, disciplines, and systems of a facility within a model that allows team members or stakeholders to collaborate throughout the project lifecycle.[134] In other words, BIM is a tool for information use, reuse and exchange of information between the parties throughout the project cycle.[135] Applying BIM in the project life cycle is vital to integrate people, systems and business structures and practices into a collaborative process to reduce waste and optimise efficiency.[136] The Victorian Government is already committed to developing a plan with industry to provide for the greater uptake of Building Information Modelling with a view to positioning Victoria as a leading user of BIM.[137]

A further extension of the use of knowledge management and building information modelling as part of the construction supply chain is the use of the digital twin. The BIM process incorporates data created during the planning and design phases, whereas the digital twin extends data capture to the construction and operational phases of the asset, informing planning and design for future projects.[138] Digital twins are created by gathering and combining real-world information about the building or structure using technologies such as 3D laser scanners, drones, sensors, cameras, and other IoT-related devices.[139]

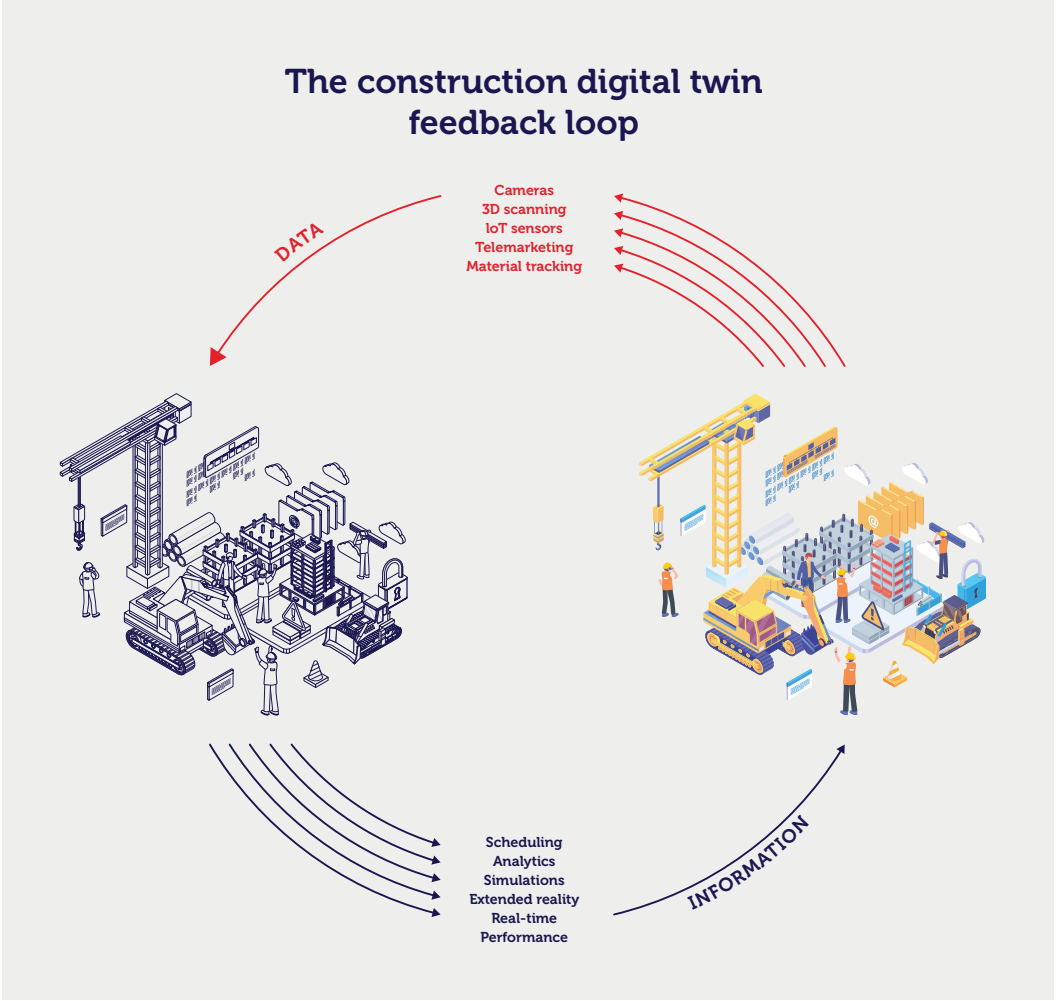
[134] Azhar, S. (2011). Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. Leadership and management in engineering, 11(3), 241-252
[135] Parvan, K. (2012). Estimating the impact of building information modeling (BIM) utilization on building project performance. University of Maryland, College Park
[136] Azhar (n134)
[137] (n 128)
[138] https://www.autodesk.com/solutions/digital-twin/architecture-engineering-construction
[139] https://constructible.trimble.com/construction-industry/what-are-digital-twins

When supported by the Internet of Things (IoT) and Artificial Intelligence (AI), a digital twin can learn from multiple sources and automatically update to reflect adjustments made to its real-world counterpart.[140] In short, digital twins provide an analytical edge to BIM activity by utilising a variety of Industry 4.0 technologies, such as IoT sensors, 3D scanning and material tracking, which feeds into the scheduling, analytics, and simulations in a more accurate, real-time loop.

An additional benefit of the use of digital technologies such as IoT and AI, is that they can deliver improved energy efficiency and lower operation costs[142] meeting the external pressure experienced by the construction industry for a smarter built environment through ambitious energy and carbon emissions agendas across the world.[143]

Using artificially intelligent tools including machine learning, has the potential to reduce construction project duration by 25 to 30%.[144] The construction industry is not able to gain significant improvement in productivity and achieve sustainability objectives because the technological solutions are not inter-connected.[145] Using artificial intelligence in the construction supply chain industry can help improve waste management and resource optimisation.[146]

Another popular approach to efficient construction supply chains is the use of off-site construction, which breaks down sections of a construction project and makes use of prefabricated components. That is, beams, columns, stairs and slabs are constructed off-site and then transported to the building site to be added to the building or infrastructure project.



[140] Ibid
[141] (n 139)
[142] Howell, S., Rezgui, Y., Hippolyte, J. L., Jayan, B., & Li, H. (2017). Towards the next generation of smart grids: Semantic and holonic multi-agent management of distributed energy resources. Renewable and Sustainable Energy Reviews, 77, 193-214
[143] Boje, C., Guerriero, A., Kubicki, S., & Rezgui, Y. (2020). Towards a semantic Construction Digital Twin: Directions for future research. Automation in Construction, 114, 103179
[144] https://inc42.com/resources/how-ai-ml-iot-sensor-can-promote-green-constructions/
[145] Ibid
[146] Wei, C., & Li, Y. (2011, September). Design of energy consumption monitoring and energy-saving management system of intelligent building based on the Internet of things. In 2011 international conference on electronics, communications and control (ICECC) (pp. 3650-3652). IEEE

This approach ensures faster construction, lower construction wastes, higher quality, higher safety and greater sustainability.[147] Additive manufacturing or 3D printing, of building sections or components is another potential time and waste saver. Work processed via traditional approaches, such as concrete mixing, building blocks and labour, could be replaced with 3D printing.[148] Printing components on-site has the potential to lead to an increase in productivity, building complexity, lower investment cost and reduction in waste.[149] However, this approach is still in its infancy and further research is needed to explore various materials that can be used, as well as the integrity of materials in larger construction projects.

Geographic Information Systems (GIS) also assist in more efficient and effective planning. GIS integrates radio frequency identification (RFID) and global positioning system (GPS) technologies that track resources and improve efficiency, reduce data entry errors caused by human transcription and reduce labour costs.[150] GIS is used to map the entire construction supply chain process, including the location of suppliers, transportation, value adding, and non-value adding activities in order to provide an ideal solution to manage costs of transportation.[151]

Researchers have also demonstrated the feasibility of using blockchain-based solutions to track and trace components of the construction supply chain (such as timber for example). These solutions aim to mitigate fraudulent activities within the construction supply chain and create more sustainable and trustworthy relationships among supply chain partners. Further possible applications of blockchain for the construction supply chain is the ability to build trust and collaboration[152] and automate traditional contracts into smart contracts.[153]

[147] Hussein, M., Eltoukhy, A. E., Karam, A., Shaban, I. A., & Zayed, T. (2021). Modelling in off-site construction supply chain management: A review and future directions for sustainable modular integrated construction. Journal of Cleaner Production, 310, 127503

[148] Singh, R., Gehlot, A., Akram, S. V., Gupta, L. R., Jena, M. K., Prakash, C., ... & Kumar, R. (2021). Cloud manufacturing, internet of things-assisted manufacturing and 3D printing technology: reliable tools for sustainable construction. Sustainability, 13(13), 7327

[149] Tay, Y. W. D., Panda, B., Paul, S. C., Noor Mohamed, N. A., Tan, M. J., & Leong, K. F. (2017). 3D printing trends in building and construction industry: a review. Virtual and Physical Prototyping, 12(3), 261-276

[150] Irizarry, J., Karan, E. P., & Jalaei, F. (2013). Integrating BIM and GIS to improve the visual monitoring of construction supply chain management. Automation in construction, 31, 241-254

[151] Li, H., Kong, C. W., Pang, Y. C., Shi, W. Z., & Yu, L. (2003). Internet-based geographical information systems system for E-commerce application in construction material procurement. Journal of Construction Engineering and Management, 129(6), 689-697

[152] Hijazi, AA, Perera, S, Al-Ashwal, AM & Neves Calheiros, R 2019, 'Enabling a single source of truth through BIM and blockchain integration', pp. 385-93

[153] Clack, C. D., Bakshi, V. A., & Braine, L. (2016). Smart contract templates: foundations, design landscape and research directions. arXiv preprint arXiv:1608.00771

Mitigation strategies for future shocks

Finally, whilst mitigation strategies have revolved around different types of technology, the proviso presented in the first case study is also applicable to the construction industry. The reliability of these technologies on the internet and interconnected systems is threatened by the challenge of ever-evolving cyber threats.[154] Common cyber security threats in the construction industry include malware, social engineering and phishing.[155] However, the construction industry does not figure much in the findings on cybersecurity. Many organisations are often unaware of the risks that lie within their own supply networks, such as failure of security or breach of privacy, including unauthorised access and interference with project tools, data and specifications.[156] The issue is compounded by low levels of transparency and monitoring of third parties.[157]

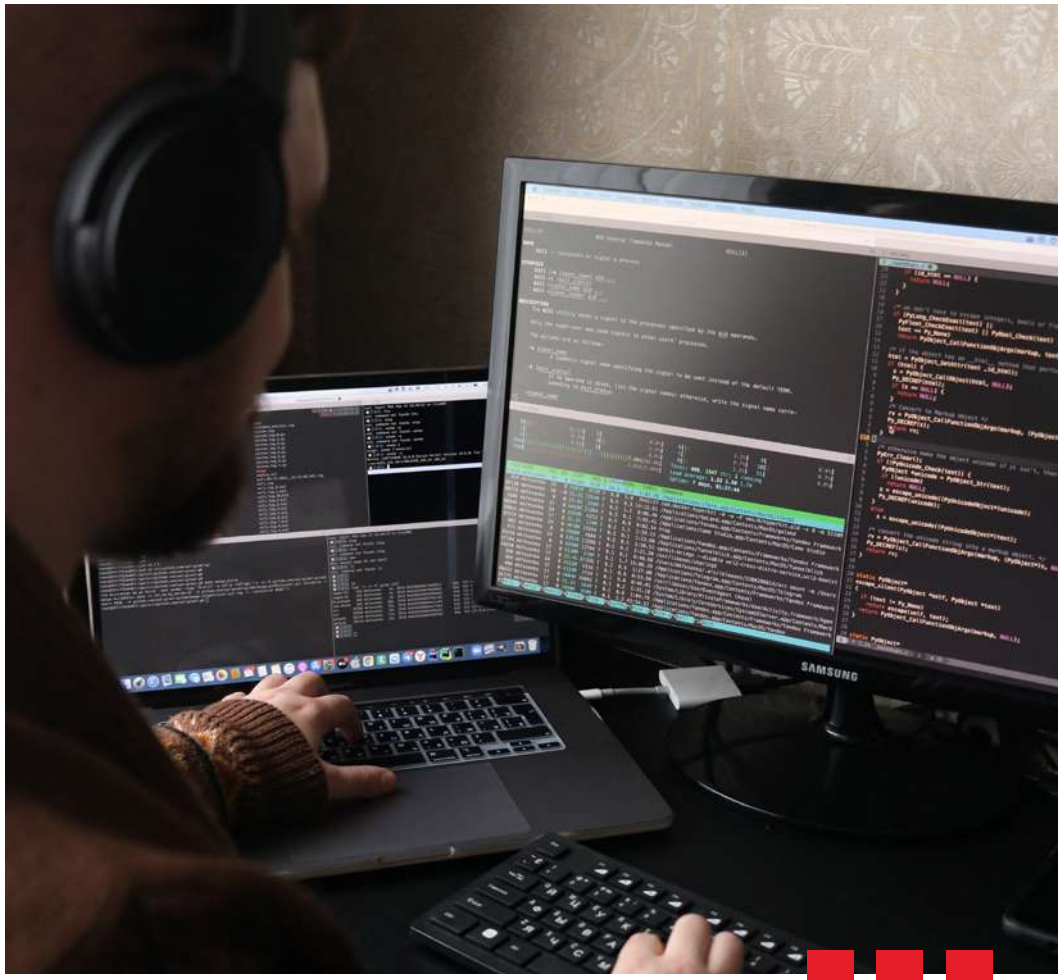
The Security Legislation Amendment (Critical Infrastructure Protection) Bill (SLACIP) passed by Parliament in December 2021, amends the Security of Critical Infrastructure Act 2018, in response to the growing threat of cyber-attacks on Australian infrastructure assets.[158] Much like the questions posed by the Australian Cyber Security Centre (ACSC) in the previous case study, additional questions to consider in the construction industry include:[159]

Where does the business operate?

Where is the business headquartered?

Has the business identified all third-parties and their role in delivering their products and services?

Does the business actively manage risks in their own cyber supply chains?



[154] Abioye, S. O., Oyedele, L. O., Akanbi, L., Ajayi, A., Delgado, J. M. D., Bilal, M., ... & Ahmed, A. (2021). Artificial intelligence in the construction industry: A review of present status, opportunities and future challenges. Journal of Building Engineering, 44, 103299

[155] Boyes, H. (2015). Cybersecurity and cyber-resilient supply chains. Technology Innovation Management Review, 5(4), 28

[156] https://www.cybersecurityconnect.com.au/strategy/7727-emerging-cyber-security-risk-in-the-supply-chain-the-next-wave-in-construction-s-perfect-storm

[157] Ibid

[158] https://www.businessaustralia.com/resources/news/construction-industry-must-bolster-cyber-security

[159] (n 111)

Case study 3: Renewable energy

Background and challenges

Rapid technology adoption has pointed out both opportunities and challenges across energy markets. Currently, the energy sector is undergoing a significant and complex transformation due to renewable energy sources.[160] These new energy sources have created new types of energy supply chains and business opportunities that never existed before.

Renewable energy is produced using natural resources that are constantly replaced and never run out. Generally, the renewable energy supply chains are used to transform the raw energy into usable energy and distribute them according to demand.[161] Hence, the key steps of renewable energy supply chains can be identified as procurement, generation, transmission, distribution and demand. The structure of each renewable energy supply chain is unique, and it is also based on specific renewable energy sources such as solar, biomass, wind, hydropower and geothermal. Among all the renewable energy sources, solar is one that is the most well-known.[162]

We are now in an era where every household and organisation has the potential to generate solar power by installing solar panels and batteries. Cities are no longer seen as just consumers of energy - there is a huge potential for prosumers (the parties who simultaneously produce as well as consume energy), even within city boundaries. It is not just solar farms and grids; each individual household and organisation is seeking opportunities to track and trade excess energy they generate. The need for deploying decentralised and distributed peer to peer energy tracking and trading platforms has already emerged - especially in cities, where the power demands are extremely high. The capability to generate power is improving but responsiveness towards energy flexibility management is also vital.

Energy is recognised as one of the critical infrastructures of Australia. As a result of cyber warfare, cyber-attacks to the energy grids have become a growing trend all around the world. Even before the pandemic, it was identified that the cyber preparedness in the Australian energy market was inadequate.[163] For instance, in 2021, CS Energy was hit by a ransomware attack which was conducted by a hacker group. Fortunately, the attack was stopped before it had the potential to shut down two major thermal coal plants which would have affected between 1.4 and 3 million homes.[164]

Achieving cyber-resilience of critical infrastructures

has been identified as a shared responsibility, with the government providing guidance and specialist assistance where necessary to owners and operators.[165]

[160] https://arena.gov.au/what-is-renewable-energy/
[161] Jelti, F., Allouhi, A., Büker, M. S., Saadani, R., & Jamil, A. (2021). Renewable power generation: A supply chain perspective. Sustainability, 13(3), 1271
[162] (n 160)
[163] https://theconversation.com/is-australias-electricity-grid-vulnerable-to-the-kind-of-cyber-attacks-taking-place-between-russia-and-the-us-119157
[164] https://www.news.com.au/technology/online/security/cs-energy-hit-by-chinese-cyberattack-that-almost-cost-3m-homes-power/news-story/a35d9903dbd87b39e48901055bc8fef3
[165] https://www.cybersecurityconnect.com.au/critical-infrastructure/7408-chinese-cyber-criminals-target-australian-power-grid

Case study 3: Renewable energy

Mitigation strategies for future shocks

Australia's renewable energy industry has shown significant growth each year. According to a report published by the Clean Energy Council,[166] more than 25% of the country's total energy generation comes from renewable energy sources with the most contributing energy source being the small-scale solar sector.

This is because even in the midst of Covid-19 in 2020, Australia invested in over 378,000 rooftop solar installations, 16 utility-scale batteries and over 23,000 small-scale batteries for Australian households.

By incorporating next-gen perovskite solar cells that generate electricity while allowing light to pass through, into new building designs in Australia, we are able to optimise solar energy generation in cities. Based on research, Central Melbourne has the potential to generate nearly 75% of its power through solar energy by installing solar panels onto roofs, walls and windows.[167] These energy targets require building more collaborative and distributed energy networks within the CBD to operationalise the energy supply chains.

Blockchain-based peer to peer energy trading mechanisms

possess the ability to remove intermediaries from the energy supply chain and provide cost savings for all the related parties by supporting decentralised and distributed energy networks. By enabling users to bid and trade the energy on the blockchain, prosumers can achieve higher transparency in the energy trading processes while improving auditing and regulatory compliance.

Australian blockchain-based energy trading platforms such as Powerledger[168]

offer different market models that support local energy trading as well as energy swapping and gifting while allowing the consumers to choose the energy they consume based on factors such as type, location and source. These blockchain-based digital marketplaces have already extended their services to support renewable energy certificates as well as time-based environmental certificates.

AGL Solar Exchange is another remarkable initiative

that was trialled in Victoria with 250 customers.[169] This is a blockchain-based energy marketplace that enables prosumers to trade the excess energy they generate in the form of solar tokens. Consumers are also able to buy tokens to fulfil their electricity needs. As the token prices are dynamically decided by the supply of and the demand for the tokens, the transactions can be more profitable than interacting directly with the grid.

In these blockchain-based solutions, tokens and cryptocurrencies or both can be used to conduct transactions. Smart contracts can be used to handle the contracts and other business logic which are specific to the platform. Some of the use cases include automating the billing processes by connecting with smart metres, other smart sensors and managing smart grid-related activities.[170] By leveraging the blockchain to support the communication and data transfer between smart devices in smart grids, a higher level of security can be achieved.

[166] https://www.cleanenergycouncil.org.au/resources/resources-hub/clean-energy-australia-report#:~:text=There%20were%20378%2C451%20rooftop%20solar,2.2%20GW%20set%20in%202019
[167] Panagiotidou, M., Brito, M. C., Hamza, K., Jasieniak, J. J., & Zhou, J. (2021). Prospects of photovoltaic rooftops, walls and windows at a city to building scale. Solar Energy, 230, 675-687
[168] https://www.powerledger.io/
[169] https://www.agl.com.au/thehub/articles/2018/12/trading-sunshine-with-agl-solar-exchange
[170] Andoni, M., Robu, V., Flynn, D., Abram, S., Geach, D., Jenkins, D., ... & Peacock, A. (2019). Blockchain technology in the energy sector: A systematic review of challenges and opportunities. Renewable and Sustainable Energy Reviews, 100, 143-174

According to the climate change mitigation strategy developed by the City of Melbourne, one of the key priorities is powering the city with 100% renewable energy by 2050.[171]

The local production of energy without importing from solar farms can significantly reduce transmission costs. Moreover, these initiatives will also contribute towards building a more resilient energy network as buildings with solar panels can avoid grid power outages by using their own energy.[172]

One of the best examples would be universities in Victoria conducting smart city microgrid trials to become Net Zero campuses and cities by 2030.[173]

As part of the Victorian government's microgrid demonstration initiative, in partnership with RMIT University, the capability to allow one solar and battery installation on an apartment building to be shared among multiple apartments has been successfully trialled in Melbourne.[174] These initiatives expect to provide significant savings for the consumer's energy costs. Furthermore, companies are also moving towards solar-powered electric vehicles to achieve their sustainability goals by reducing the net carbon emissions throughout supply chains.[175]

[171] https://www.melbourne.vic.gov.au/about-council/vision-goals/eco-city/Pages/climate-change-mitigation-strategy.aspx
[172] https://www.abc.net.au/news/science/2021-11-10/rooftop-solar-mcg-could-help-melbourne-reach-net-zero/100602676
[173] https://arena.gov.au/blog/smart-city-microgrid-trial-a-step-towards-100-renewable-university
[174] https://www.energymagazine.com.au/new-microgrid-tech-brings-solar-energy-to-melbourne-renters/
[175] https://www.foodprocessing.com.au/content/materials-handling-storage-and-supply-chain/news/electric-truck-for-vb-beer-deliveries-in-melbourne-135476928

Building resilient supply chains through technology

Resilient supply chains are a crucial factor in rebuilding our economies

As we discussed through food service & hospitality, construction and renewable energy case studies, these resilient supply chains cannot be built without leveraging secure and smart digital infrastructures. In this section, we reflect on how each technological advancement can contribute to building resilient supply chains for the Melbourne CBD.

Transparency and authentication

Due to the complexity of global supply chains, there is a higher likelihood of inefficiencies and delays occurring due to the ineffective processes related to authentications. This is mainly because of the paper credentials which are still being used in this industry which require manual verification. These paper-based authentication processes have introduced a significant security vulnerability (eg through easily forgeable paper-based credentials) to supply chains as well as underlying business infrastructures. Global supply chains require a tamper-proof, machine verifiable approach to authenticate and securely manage user credentials. Therefore, digitising paper credentials are essential for building secure and resilient global supply chains.

One approach to do this is through **verifiable credentials** where blockchain-based decentralised digital identities can be assigned to individuals, entities, devices and other assets to track cross-border movements. Blockchain is a distributed ledger for maintaining and tracking a permanent and tamper-proof record of transactional data, where a distributed ledger is a special type of database shared, replicated, synchronised, and maintained by the participants of a decentralised network.[176] Blockchain does not have a single point of failure and acts as a single source of truth.[177]

[176] Nakamoto, S. 2008. “Bitcoin: A Peer-to-Peer Electronic Cash System”
[177] The Economist. 2015. “The Trust Machine – The Promise of the Blockchain.” October 31

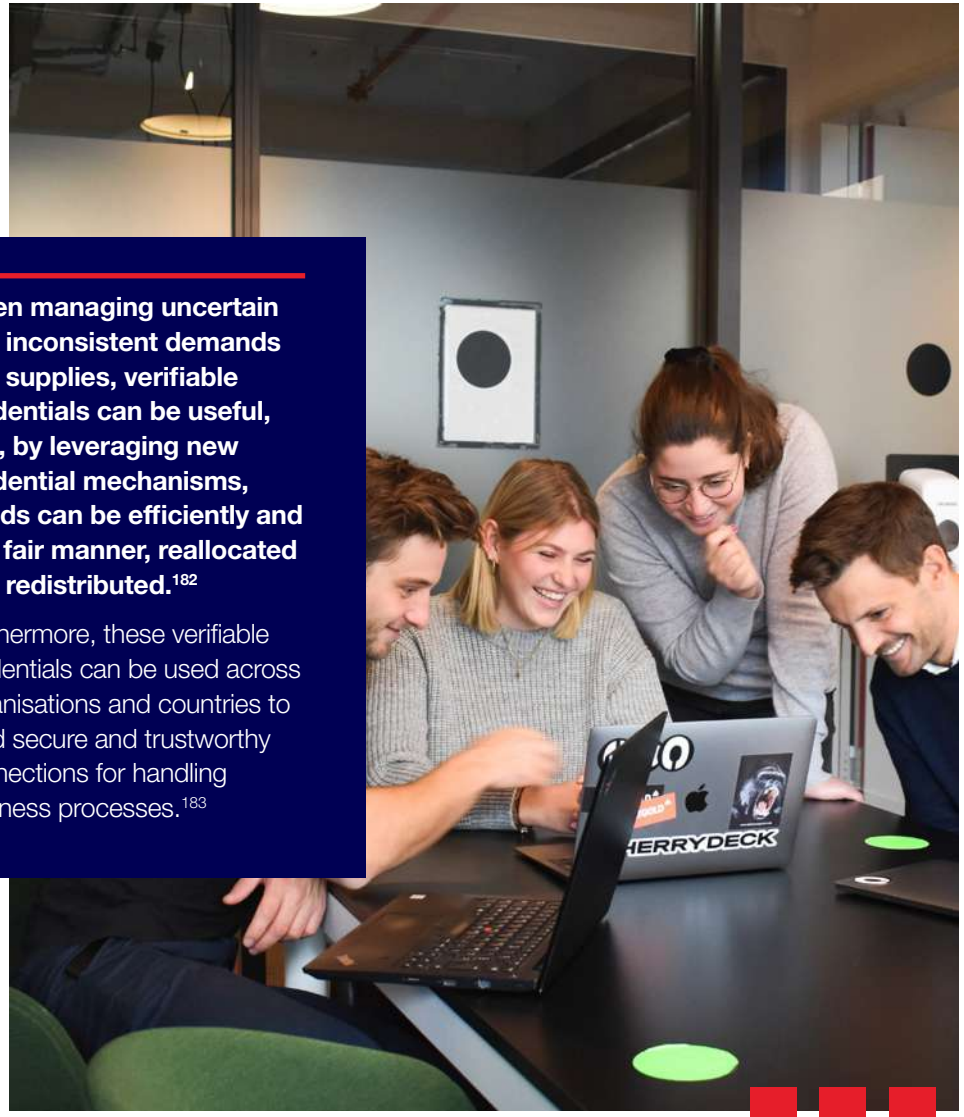
Any authorised party can review the data stored on the chain. The information stored on the chain cannot be deleted or tampered and can only be updated after a rigorous validation by the network consensus algorithms.[178] Blockchains can be public, private or permissioned, depending on who has the ability to be a user of, or run a node on, the blockchain. Public blockchains (eg Bitcoin) allow every node in the network to conduct transactions and participate in the consensus process. Private blockchains (eg Multichain) only allow a limited number of approved nodes to participate in the consensus process (such as a number of banks that agree to a network). Permissioned blockchains (eg Ripple), a mixture of public and private blockchains, allow anyone to join the permissioned network after a verification of its identity; such blockchains can also allocate designated permissions to perform only certain activities on the network.[179]

As a key component in transparent supply chains, when applying verifiable credentials, every individual and the entity within the distributed supply chain network receives a unique and decentralised identity that supports the creation of traceable and transparent supply chains.

There are many uses for verifiable credentials within the supply-chain space. One of the key use cases is standardising the documentation process by converting them into verifiable credentials. These immutable records have the potential to avoid forgeries, counterfeits and other illegal activities that occur when moving products.[180] The pandemic has emphasised the need for building agile and resilient supply chains that can dynamically respond to the crisis in the future.[181] Hence, the verifiable credentials can be leveraged to build data infrastructures and derive business analytics to support rapid decision making in balancing demand and supply.

When managing uncertain and inconsistent demands and supplies, verifiable credentials can be useful, and, by leveraging new credential mechanisms, goods can be efficiently and in a fair manner, reallocated and redistributed.[182]

Furthermore, these verifiable credentials can be used across organisations and countries to build secure and trustworthy connections for handling business processes.[183]



[178] Gupta, M. 2018. Blockchain for Dummies. 2nd IBM limited ed. Hoboken, New Jersey: John Wiley & Sons, Inc
[179] Ibid
[180] Chang, Y., Iakovou, E., & Shi, W. (2020). Blockchain in global supply chains and cross border trade: a critical synthesis of the state-of-the-art, challenges and opportunities. International Journal of Production Research, 58(7), 2082–2099. https://doi.org/10.1080/00207543.2019.1651946
[181] Abid, A., Cheikhrouhou, S., Kallel, S., & Jmaiel, M. (2022). NovidChain: Blockchain-based privacy-preserving platform for COVID-19 test/vaccine certificates. Software, Practice & Experience, 52(4), 841–867. https://doi.org/10.1002/spe.2983
[182] Chang (n 180)
[183] Ibid

Another technological approach that modern supply chains can utilise to manage digital ownership records of unique assets is through the incorporation of blockchain-based NFTs. “Non-fungible tokens are blockchain assets that are designed not to be equal. Non-fungibility is the USP of such investments. This characteristic is of enormous importance when we are talking about rare and unique collectibles.

The value of such items is derived from their non-fungibility”.[184] First, the producer of the physical asset can create a digital documentation of that asset and record the ownership of that asset on the blockchain. As soon as ownership of that asset changes, it can be reflected on the blockchain through transactions. When that asset is in transit, the responsible entities for that asset also can be securely recorded for tracking purposes.

NFT-based tracking can be useful for transparency and visibility in supply chains where unique or significantly expensive goods are being handled. Many luxury brands have already begun exploring the potential of NFTs.[185]

Through NFT-based ‘product passports’, it is also possible to store information such as warranty, the origin of the product, the material used, the manufacturing process, sustainability and other certifications related to the product.[186] During the pandemic, online shopping significantly increased in Victoria[187] and this trend continued across the globe.[188] NFTs can be used to protect consumers from online counterfeit purchases and provide them with trustworthy information, so they can easily authenticate the goods by themselves.

Regulatory frameworks currently in use need to be enabled to accept digitised information for authentication and it is vital that trading mechanisms are standardised. It is not possible to deploy a single blockchain-based supply chain solution if multiple standards exist among individual countries or states.

Supply chains move not only goods but also information on those goods across borders. Therefore, supply chains would benefit from **TradeTech** applications. TradeTech applications are known to reduce transaction costs and increase transparency for key stakeholders as well as reduce the regulatory and compliance burdens in businesses.[189]

Blockchain-based supply chain management solutions can be identified as one of the key applications of TradeTech which provides a new ‘digital services infrastructure for international trade in goods’. Through blockchain-based data provenance, trustworthy relationships can be formed in situations where the key entities in the supply chain network do not trust each other.

Furthermore, we also have to ensure that the blockchain-based solutions are compliant with the existing regulatory framework, supply chain and trade-related laws.

[184] Arora, A., Kanisk, & Kumar, S. (2021). Smart Contracts and NFTs: Non-Fungible Tokens as a Core Component of Blockchain to Be Used as Collectibles. In Cyber Security and Digital Forensics (pp. 401–422). Springer Singapore. https://doi.org/10.1007/978-981-16-3961-6_34

[185] https://www.adidas.com/prada-nft

[186] Valeonti, F., Bikakis, A., Terras, M., Speed, C., Hudson-Smith, A., & Chalkias, K. (2021). Crypto Collectibles, Museum Funding and OpenGLAM: Challenges, Opportunities and the Potential of Non-Fungible Tokens (NFTs). Applied Sciences, 11(21), 9931–. https://doi.org/10.3390/app11219931

[187] https://7news.com.au/the-morning-show/the-rise-in-counterfeit-goods-during-covid-19-and-tips-to-ensure-your-products-are-authentic-c-1260541

[188] Hao, N., Wang, H. H., & Zhou, Q. (2020). The impact of online grocery shopping on stockpile behavior in Covid-19. China Agricultural Economic Review, 12(3), 459–470. https://doi.org/10.1108/CAER-04-2020-0064

[189] Allen, D. W., Berg, C., Davidson, S., Novak, M., & Potts, J. (2019). International policy coordination for blockchain supply chains. Asia & the Pacific Policy Studies, 6(3), 367-380

End-to-end visibility and connectivity

To build resilient supply chains, the business should have the technological capabilities for real-time monitoring of their supply chains to achieve end to end visibility of their supply chain operations.[190]

As soon as a specific supply chain operation gets disrupted, businesses should have alternative mechanisms in place to respond to that disruption. This requires businesses to be ready for any unexpected situation through visualisation, scenario planning, simulations and network modelling to improve supply chain design in the long term. Key emerging technological applications to support visualisation and simulation are **supply chain control towers** and **supply chain digital twins**.

Supply Chain Control Towers (SCCT)

are integrated and personalised data dashboards that visualise the key business analytics for various stakeholder groups. Capgemini defines the SCCT as "a central hub with the required technology, organisation and processes to capture and use supply chain data to provide enhanced visibility for short and long term decision making that is aligned with strategic objectives". These supply chain towers can be managed by multiple organisations to support a quick and collaborative decision-making process. These solutions aim to provide end-to-end visibility and enhance resilience throughout the supply chain operations.

It is difficult to get digital transformation right. Any digital transformation as a process faces two significant organisational barriers:

1. **inertia -** the structural components of the organisation, both tangible (eg means of production) and intangible (eg organisational culture), are so embedded within everyday practices that they stifle the innovative and disruptive power of digital technologies; and

2. **resistance –** demonstrated by employees, is a product of inertia rooted in everyday work that cannot be addressed by simply altering the behaviour of employees, rather through alteration of processes to enable flexibility in the face of change.[191]

[190] Christopher (n 15)

[191] Bhosle, G., P. Kumar, B. Griffin-Cryan, R. Van Doesburg, M. Sparks, and A. Paton. 2011. "Global Supply Chain Control Towers: Achieving End-toEnd Supply Chain Visibility." In Capgemini Consulting White Paper. London, UK: Capgemini Consulting

Digital twins

leverage real-time data and machine learning to generate business intelligence for efficient decision making. Victoria already has started exploring digital twins to recreate Victoria online to enhance the collaboration between government, industry and the community.[192] As demonstrated through the proof of concept of the Fishermans Bend Digital Twin project,[193] the same technology can be used to simulate the supply chain ecosystem for Victoria. Digital twins have also been created at the product level to identify the defects in the original product reliably and efficiently in manufacturing processes within Australia.[194]

The AI techniques involved in digital twins can be roughly categorised into four classes: supervised learning, unsupervised learning, reinforcement learning and other intelligent computational methods. Supervised learning algorithms refer to machine learning methods in which models are trained using labels whereas in unsupervised learning methods, there is no labelling of data required, and the model is expected to infer patterns from the unlabelled input data.[195] Reinforcement learning algorithms are concerned with how intelligent agents ought to take actions in an environment in order to maximise the notion of cumulative reward.[196] Supervised learning remains the most stable and extensively used approach in digital twins with reinforcement learning being advantageous in scenarios with complex environments and long response cycles; and, unsupervised and semi-supervised learning is proactive in state detection and lifetime prediction.[197]

Logistic companies should have advanced technical capabilities and resources in place to ensure that end-to-end visibility and security can be provided for products.

If products in transit are highly valuable items, then the logistics company should have the capabilities to provide real-time tracking information through various modes of transportation.

If items that are being transferred are perishable, then these companies should also have **smart sensors and IoT** devices to track the environmental changes and other factors while in transit and storage.

The secure integration of tracking information with stakeholder information systems is also important and should be available to multiple stakeholder groups such as retailers and consumers.

A blockchain-based decentralised product tracking system would be a secure option to consider for end-to-end visibility and security.

In this system, data is not collected, stored and managed centrally rather data is protected and shared among only the parties that are involved in the transaction[198] providing a robust and strong cybersecurity solution and high level of privacy protection.[199] Cybersecurity across the supply chain is a complex construct that draws on and includes several different but interrelated factors and their elements.[200] Digital IoT technologies present new cyber risk in the supply chain of the digital economy which are often not visible to companies participating in the digital supply chains.[201] The main elements associated with cybersecurity are assets involved in cyber-attacks, system vulnerabilities, cyber threats, risks and countermeasures where physical systems such as machines, shop floors, plants; are connected with each other via the Internet.[202]

[192] https://www.land.vic.gov.au/maps-and-spatial/projects-and-programs/digital-twin-victoria
[193] https://www.land.vic.gov.au/maps-and-spatial/projects-and-programs/digital-twin-victoria/fishermans-bend-digital-twin
[194] https://www.csiro.au/en/news/news-releases/2019/australian-digital-twin-technology-set-to-transform-manufacturing
[195] Huang, Z., Shen, Y., Li, J., Fey, M., & Brecher, C. (2021). A survey on AI-driven digital twins in industry 4.0: Smart manufacturing and advanced robotics. Sensors (Basel, Switzerland), 21(19), 6340–. https://doi.org/10.3390/s21196340
[196] Ibid
[197] Ibid
[198] Kshetri, N. (2017). Blockchain's roles in strengthening cybersecurity and protecting privacy. Telecommunications Policy, 41(10), 1027–1038. https://doi.org/10.1016/j.telpol.2017.09.003
[199] Schutzer, D. (2016). CTO Corner: What is a Blockchain and why is it important? FSRoundtable. Retrieved from http://fsroundtable.org/cto-corner-what-is-a-blockchainand-why-is-it-important//
[200] Melnyk (n 69)
[201] Radanliev, P., De Roure, D., Page, K., Nurse, J., Montalvo, R. M., Santos, O., Maddox, L. T., & Burnap, P. (2019). Cyber Risk at the Edge: Current and future trends on Cyber Risk Analytics and Artificial Intelligence in the Industrial Internet of Things and Industry 4.0 Supply Chains. https://doi.org/10.1186/s42400-020-00052-8
[202] Lezzi, M., Lazoi, M., & Corallo, A. (2018). Cybersecurity for Industry 4.0 in the current literature: A reference framework. Computers in Industry, 103, 97–110. https://doi.org/10.1016/j.compind.2018.09.004

Efficiency through automation

Digital supply chains all around the world have been revolutionised by automated or driverless technologies such as autonomous vehicles, robotics and drones. These autopilot driverless technologies are already operationalised at some distribution centres in Melbourne.

Connected and Autonomated vehicles

have been explored within the warehouses in Melbourne to automate towing, lifting, placing products, and picking orders for customers.[203]
It is reported that these autonomous vehicles have significantly improved the overall efficiency by reducing the manual workload within the distribution centres. It combines autonomous technology that enables all driving tasks without human intervention, with connected vehicle technology that enables bidirectional communication with the surrounding traffic conditions.[204] Connected vehicle technology enables communication between nearby vehicles and reduces uncertainties in their behaviours, which leads to significant reduction in reaction time and smoother braking without compromising safety.[205]
It holds great potential for improving the capacity, safety, efficiency, and stability of transportation systems with lower environmental impact while addressing the limitations of current perishable or semi-perishable supply chain systems and human-driven trucks.[206]
Automated vehicles consist of autopilot software, amenity software, communication and vehicle control and network control systems, learning and mapping software which can have security vulnerabilities and be exploited by malicious users.[207]

Robots using AI

are being used in warehouses and distribution centres in Melbourne. Supermarkets in Australia have already invested in robots for picking and packing items. Some companies have been able to reduce the stock levels by 20% due to the fact that robots can dispatch and resupply quickly.[208] There is a huge demand post pandemic, for the design and development of fast solutions for the manufacturing industry. Applications of new technological solutions such as robots to assist the manufacturing processes and the quality inspection for dangerous spaces has been also considered.[209]

Drones

are used within the warehouses for stock-taking and other inventory management activities as a secure and efficient alternative to manual stock-taking processes traditionally conducted by workers. In Australia, drone deliveries have already been conducted with full regulatory approval in some states such as Canberra and Queensland.[210] Some of the items they have delivered are food, coffee and over the counter medicine. Drones can denote gains in delivery time, allowing a ‘just-in-time’ model, operating through a ‘pull’ system, reducing the need for inventories and costs.[211]
The Australian medical drone logistic company, Swoop Aero is changing the world through transporting medicines, vaccines and pathology samples by controlling drones from a warehouse in Port Melbourne.[212] In 2020, they delivered 32,000 vials of vaccines across three countries and helped process 50,000 HIV testing samples.[213]
Drones are considered a quick and efficient approach for delivering medical products, especially to rural areas.

[203] https://www.co-optoyota.com.au/news/toyota-s-warehouse-on-autopilot-in-2020/
[204] Talebpour, A., & Mahmassani, H. S. (2016). Influence of connected and autonomous vehicles on traffic flow stability and throughput. Transportation Research Part C: Emerging Technologies, 71, 143-163. doi:10.1016/j.trc.2016.07.007
[205] Kloostra, B., & Roorda, M. J. (2019). Fully autonomous vehicles: analyzing transportation network performance and operating scenarios in the Greater Toronto Area, Canada. Transportation planning and technology, 42(2), 99-112
[206] Zhao, J. & Lee, J. Y. (2022) Effect of Connected and Autonomous Vehicles on Supply Chain Performance. Available at SSRN: https://ssrn.com/abstract=4029680 or http://dx.doi.org/10.2139/ssrn.4029680
[207] https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/Vehicles_advice_submission_-_MacroPlan.pdf
[208] https://www.smh.com.au/business/companies/pick-pack-and-stack-the-robot-warehouse-has-arrived-20190329-p518t4.html
[209] Huang, Z.; Shen, Y.; Li, J.; Fey, M.; Brecher, C. AI-Driven Digital Twins. Sensors 2021, 21, 6340. https://doi.org/10.3390/s21196340
[210] Allen, D. W. ., Berg, C., Davidson, S., Novak, M., & Potts, J. (2019). International policy coordination for blockchain supply chains. Asia & the Pacific Policy Studies, 6(3), 367–380. https://doi.org/10.1002/app5.281
[211] Mora, P., & Araujo, C. A. S. (2021). Delivering blood components through drones: A lean approach to the blood supply chain, Supply Chain Forum, 1–11. https://doi.org/10.1080/16258312.2021.1984167
[212] https://www.suasnews.com/2021/12/swoop-aero-obtains-beyond-visual-line-of-sight-approval-in-australia/
[213] https://discover.agl.com.au/advancing-australia/meet-the-high-flying-aussies-transforming-medical-supply-delivery/

Predictive analytics and forecasting

Uncertain supply and demand throughout supply chains demonstrates the importance of embedding predictive analytics to supply chains.

The need for advanced analytics in supply chain management is identified across many industries.[214]

Companies are currently exploring **artificial intelligence** and **machine learning** to analyse the data gathered from each and every touchpoint of supply chains.

Furthermore, AI and ML provide the technological foundations for emerging technology solutions such as supply chain control towers and digital twins as well as automotive solutions such as autonomous vehicles and drones described earlier.[215] There are five streams which machine learning can be classified into:

1. **providing additional information to assist solution strategies, such as learning which algorithm is likely to perform better on an instance of the problem before making an attempt to solve it**
2. **accelerating the performance of an algorithm**
3. **improving the robustness of solutions**
4. **producing the optimal or close to optimal solutions of all or a subset of decision variables of a combinatorial optimisation problem**
5. **the optimal objective value of a combinatorial optimisation problem.[216]**

Even before the pandemic, major Australian supermarkets enabled AI-based advanced analytics by building enterprise data platforms with tech giants such as Microsoft.[217] These solutions were built to support the forecasting of the on-shelf availability of the product and also support personalised offers based on purchase history as well as other external factors. During the pandemic, some supermarkets in Australia moved to cloud-based platforms[218] and explored the potential of automating food replenishment processes through AI-based cloud platforms.[219]

Some organisations have formed rapid response teams who are dedicated to monitoring the supply and demand inconsistencies and labour shortages before they disrupt operations.[220] Even now at the end of the pandemic, it is going to be difficult to predict the percentage of consumers who opt in to use online deliveries with extra shipping costs and delays, compared to consumers who want to continue with in-shop experiences. Therefore, business intelligence and data analytics solutions can be deployed to predict these numbers and develop new supply chain strategies.

[214] https://www.mckinsey.com/business-functions/operations/our-insights/how-covid-19-is-reshaping-supply-chain
[215] Huang (n 195)
[216] Abbasi, B., Babaei, T., Hosseinifard, Z., Smith-Miles, K., & Dehghani, M. (2020). Predicting solutions of large-scale optimization problems via machine learning: A case study in blood supply chain management. Computers & Operations Research, 119, 104941–. https://doi.org/10.1016/j.cor.2020.104941
[217] https://www.afr.com/technology/coles-turns-to-ai-to-transform-grocery-shopping-20190704-p5249q
[218] https://www.afr.com/technology/woolworths-plans-ai-driven-stores-as-cloud-transformation-bears-fruit-20201030-p56a92
[219] https://www.zdnet.com/article/coles-automates-fresh-produce-replenishment-process-with-cloud-ai-based-platform/
[220] (n 61)

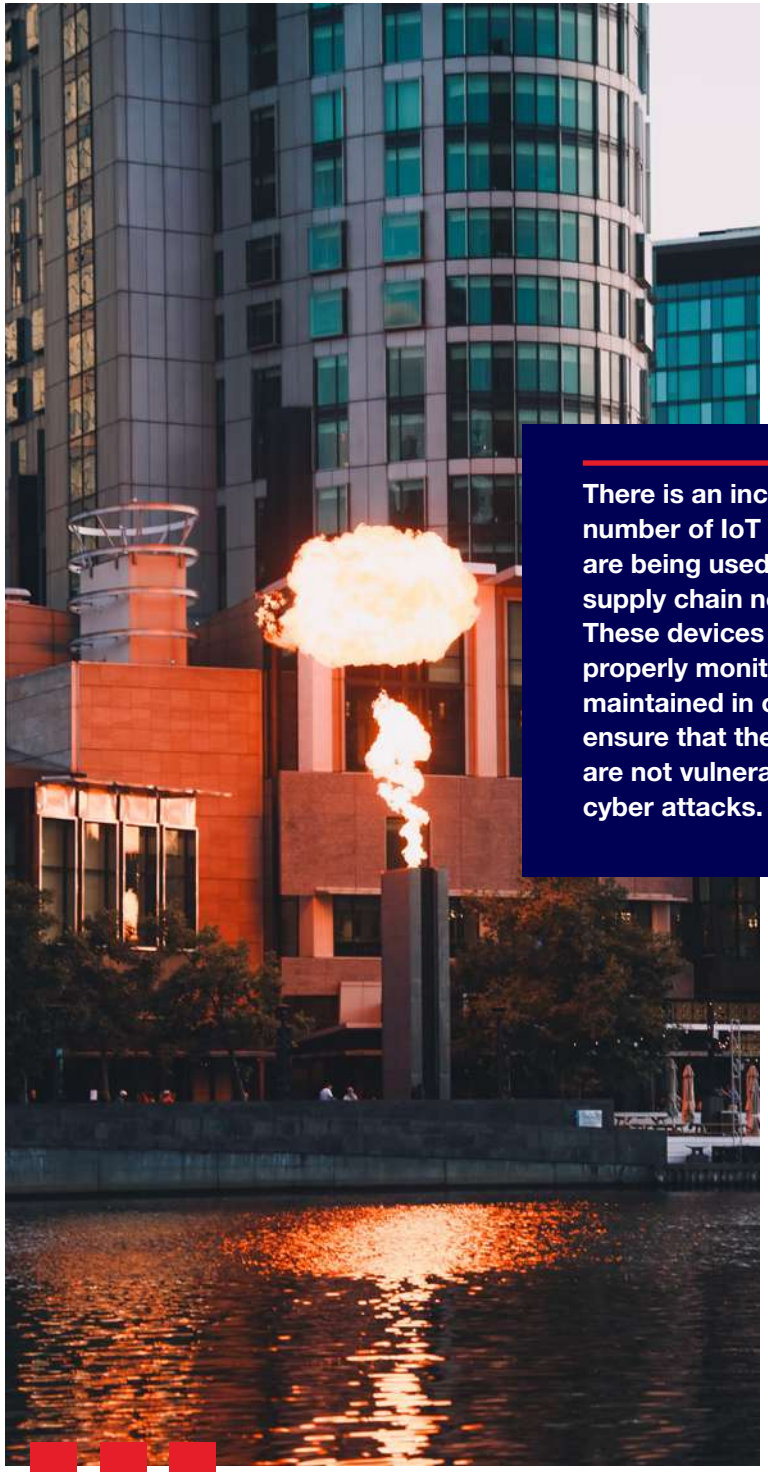
Operational-resilience through cyber-resilience

Cybersecurity issues represent a complex challenge for all companies committing to Industry 4.0 paradigm.[221] This challenge increased multifold with COVID-19.[222] With global supply chain attacks surging by 51% in H2 2021,[223] cyber security is now a supply chain issue.[224] Cyber-resilience can be defined as ' the capability of a supply chain to maintain its operational performance when faced with cyber-risk'. Cybersecurity resilience is required to safeguard from different types of cyber risks and their points of penetration, propagation levels, consequences and mitigation measures.[226]

Protecting the supply chain ecosystem from security vulnerabilities is one of the key aspects of achieving supply chain resilience. In order to avoid counterfeit products and protect Australian businesses, Australia has already explored the blockchain-based Smart Trade Marks to achieve consumer confidence in Australian-made products.[227] By embedding the blockchain-based Smart Trade Marks to Australian products, both businesses and consumers are able to easily authenticate these products and differentiate them from any counterfeits instantly by checking the registered Australian trademark. These solutions not only contribute to creating more transparent supply chains but also provide solutions for securing the invaluable intellectual property rights[228] of Australian businesses as well.

In order to build more secure global supply chains, we also have to rely on global data standards.[229] These data standards focus on providing unique identifications to everything (product, documents, shipments etc) involved in supply chains. Data standards are currently able to capture data through barcodes, RFID and IoT technologies and support the data exchange process among stakeholders. In Australia, distributed trust systems, blockchain and distributed ledger technology, and verifiable credentials are currently being explored to be used for information management, credential exchange, digital authentications and conformity of business interactions.[230]

[221] Lezzi (n 202)
[222] Ibid
[223] https://www.infosecurity-magazine.com/news/global-supply-chain-attacks-surge/
[224] Melnyk (n 69)
[256] Khan, O., & A. Sepúlveda Estay, D. (2015). Supply Chain Cyber-Resilience: Creating an Agenda for Future Research. Technology Innovation Management Review, 5(4), 6–12. https://doi.org/10.22215/timreview/885
[226] Ghadge, A., Weiß, M., Caldwell, N. D., & Wilding, R. (2020). Managing cyber risk in supply chains: a review and research agenda. Supply Chain Management, 25(2), 223–240. https://doi.org/10.1108/SCM-10-2018-0357
[2227] https://www.minister.industry.gov.au/ministers/karenandrews/media-releases/helping-better-protect-australian-businesses-counterfeiting
[228] Cohen, M. A., & Rogers, P. C. (2021). When Sino-American Struggle Disrupts the Supply Chain: Licensing Intellectual Property in a Changing Trade Environment. World Trade Review, 20(2), 238–257. https://doi.org/10.1017/S1474745620000531
[229] Application of Global Data Standards for Supply Chain Connectivity. (2015). MENA Report
[230] https://nata.com.au/files/2022/01/Main_report_Digitalisation_of_Conformance_and_Accreditation_Processes_based_on_ISOIEC_Global_Data_Standards.pdf



There is an increased number of IoT devices that are being used throughout supply chain networks. These devices should be properly monitored and maintained in order to ensure that the devices are not vulnerable to cyber attacks.

As humans are always the weakest link in cyberspace, employees across supply chains should possess sufficient knowledge and cyber security skills to protect themselves from phishing and other cyber attacks. Therefore, through the security policy of organisations, security best practices could be enforced such as changing default passwords, enabling Two-Factor Authentication and using a password manager to generate, save and use unique passwords. One of the paradigm shifts that happened with the pandemic was 'working from home'. Therefore, as the majority of employees are working from their homes, remote access technologies should also be monitored.

Industry is moving towards more secure Inventory Tracking Systems leveraging new technologies. Australian retailers have already started exploring the reduction of thefts by installing radio frequency identifications or 'smart' tags as 85% of the inventory shrinkage is due to either staff or customer theft.[231] Many companies are now invested in cloud-based solutions, and digitalised information stored on these platforms requires proper security controls in place to ensure that their systems are not vulnerable to cyber-attacks.

According to the Australian Cyber Security Centre, approximately one-quarter of reported cyber incidents in Australia are related to targeting the critical infrastructures and essential services such as health care, food distribution and energy sectors.[232] Fraud, online shopping scams and online banking scams were among the highest reported cybercrime types during the pandemic. The Australian Cyber Security Centre also advises organisations to ensure that patches and updates for security vulnerabilities are applied within two weeks of release or 48 hours if an exploit exists, as malicious actors are monitoring these vulnerabilities regularly.

In Industry 4.0, using a cognitive architecture for supply chains allows learning algorithms and technologies to be changed quickly and re-used on different platforms. This cognitive architecture creates multi-vendor production systems providing real-time synchronised coexistence of the virtual and physical dimensions requiring the supply chains to be self-aware. This then necessitates a dynamic and self-adapting system supported with artificial intelligence and Machine Learning (AI/ML) and real time intelligence for predictive cyber risk analytics.[233]

[231] https://www.afr.com/companies/retail/myer-takes-stock-control-hightech-20190314-h1cd0u
[232] https://www.cyber.gov.au/acsc/view-all-content/reports-and-statistics/acsc-annual-cyber-threat-report-2020-21
[233] Radanliev, P., De Roure, D., Page, K., Nurse, J., Montalvo, R. M., Santos, O., Maddox, L. T., & Burnap, P. (2019). Cyber Risk at the Edge: Current and future trends on Cyber Risk Analytics and Artificial Intelligence in the Industrial Internet of Things

Experimenting with the metaverse to build new online shopping experiences

While Victoria is recovering from the COVID -19 pandemic, plans are currently underway to revitalise the Melbourne CBD by introducing loyalty schemes, targeted promotions and discounted entries.[234] to attract consumers back to bricks and mortar shops. Research has shown that the popularity of online shopping will continue even after the pandemic[235] with an 8.9% growth of online shopping in the Australian market in 2022.[236] Therefore, retailers must focus on innovative **online shopping experiences** for consumers and invest in **resilient and secure digital infrastructures** to support them.

Modern supply chains drive customer satisfaction. Therefore, products, personalised product suggestions and offers should be presented to consumers while captivating them through an interactive online shopping experience (3-D spatial web, metaverse) that make them stay longer and order more products.

The existing Augmented Reality (AR) solutions should be enhanced to gain a competitive advantage and provide a more realistic experience for consumers. Major shopping centres can benefit from developing digital twins to attract more customers so they can try out new products and services in the comfort of their homes. Retailers should also explore opportunities in the metaverse to build a virtual presence by creating unique digital experiences for targeted tech-savvy consumer groups. These unique experiences that retailers can create in the metaverse are endless. For instance, major Australian fashion brands can reach out to their consumers through virtual fashion shows and hotels and nightclubs can invite consumers to experience their services through a virtual lens.

The metaverse is defined by Mystakidis (2022) as " the post-reality universe, a perpetual and persistent multiuser environment merging physical reality with digital virtuality. It is based on the convergence of technologies that enable multisensory interactions with virtual environments, digital objects and people such as virtual reality (VR) and augmented reality (AR). Hence, the metaverse is an interconnected web of social, networked immersive environments in persistent multiuser platforms. It enables seamless embodied user communication in real-time and dynamic interactions with digital artifacts. Its first iteration was a web of virtual worlds where avatars were able to teleport among them. The contemporary iteration of the metaverse features social, immersive VR platforms compatible with massive multiplayer online video games, open game worlds and AR collaborative spaces."[237]

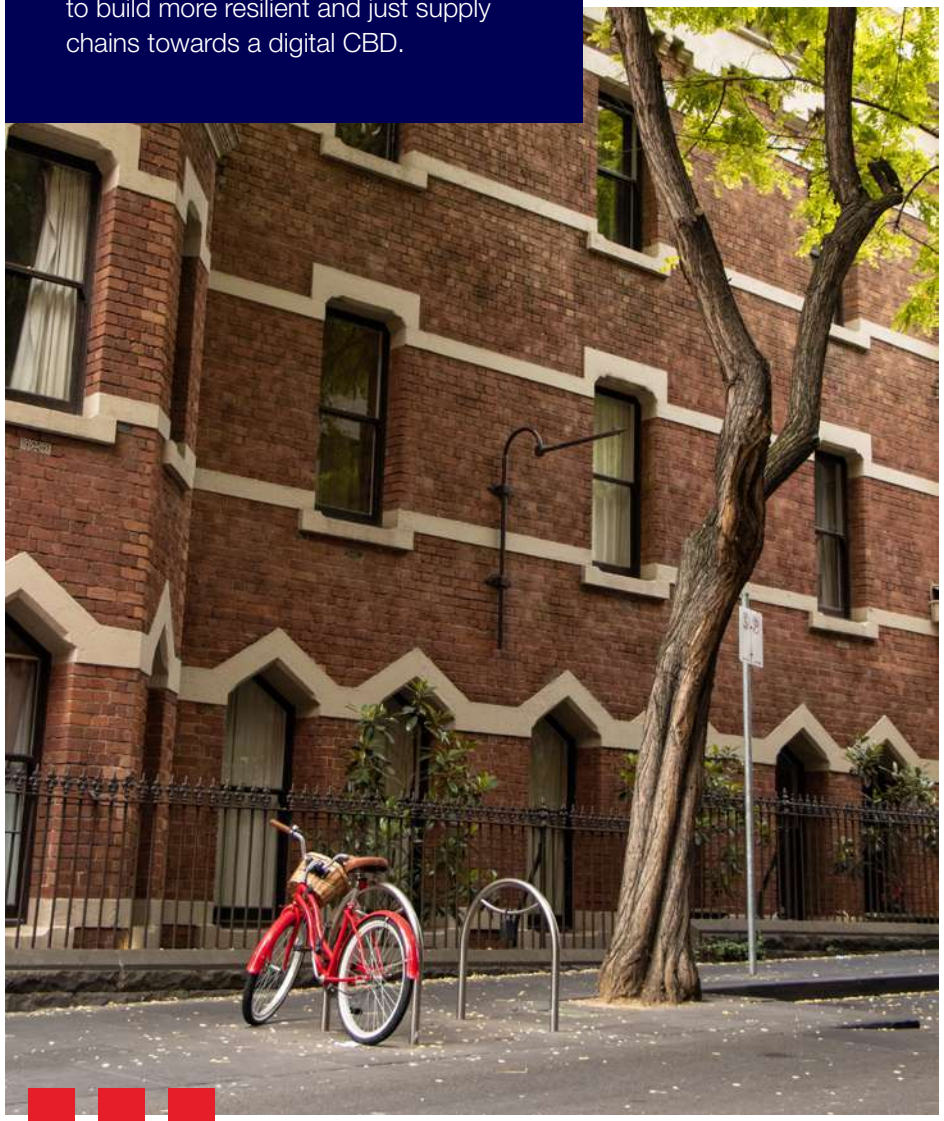
Retailers of unique and valuable products such as luxury items, can add NFT based product passports to products as value adding and sell those items for premium prices. Consumers who require an extra layer of authentication and digital ownership for luxury goods can pay extra to own these items. Retail supply chains also need to incorporate Decentralised Finance (DeFi) and cryptocurrencies to facilitate more payment options to consumers.

[234] https://www.budget.vic.gov.au/revitalising-our-cbd
[235] https://www.mckinsey.com/business-functions/marketing-and-sales/our-insights/the-great-consumer-shift-ten-charts-that-show-how-us-shopping-behavior-is-changing
[236] https://www.ibisworld.com/au/market-size/online-shopping/
[237] Mystakidis, S. Metaverse. Encyclopedia 2022, 2, 486–497. https://doi.org/10.3390/ encyclopedia2010031

Recommendations and future directives

Based on the strategic analysis in this report,

we propose the following recommendations and future directives to build more resilient and just supply chains towards a digital CBD.



Recommendations

Recommendation 1: Supply chain data governance framework

Currently there is an enormous amount of data that is generated by supply chains. This data could be utilised by more actors within the city to support growth and build better and more resilient supply chains.

Therefore, it is recommended that a data governance framework is developed to create a common pool resource from data and define clear ownership rights as to who controls and governs the data.

Recommendation 2: Standardise supply chain cyber security requirements

Standardising the cyber security requirements for different supply chains would help to support cyber resilience and mitigate against risks when operationalising emerging technologies.

Government and industry could collaborate on this to ensure requirements can support a diverse ecosystem of SME's and larger corporations.

Recommendation 3: NFTs as digital twins

Digital twins are essential to the use of emerging technologies. It has been identified that NFTs are the key infrastructure that provides the most secure form of digital twins in supply chains.

Recognising NFTs as the industry standard for digital twins within supply chains would help to mitigate against fraud, theft, and loss - ultimately, creating more resilient supply chains for the future.

Recommendation 4: Melbourne as a testbed for autonomous vehicles

As stated within the report, supply chains all around the world have been revolutionised by automated or driverless technologies such as autonomous vehicles, robotics and drones.

Victoria could develop the policies, shared infrastructure and put in place incentives to trial this technology within Melbourne and position the city as one of the global leaders in autonomous last mile-delivery.

Recommendations

Recommendation 5: Uplift digital skills within supply chains

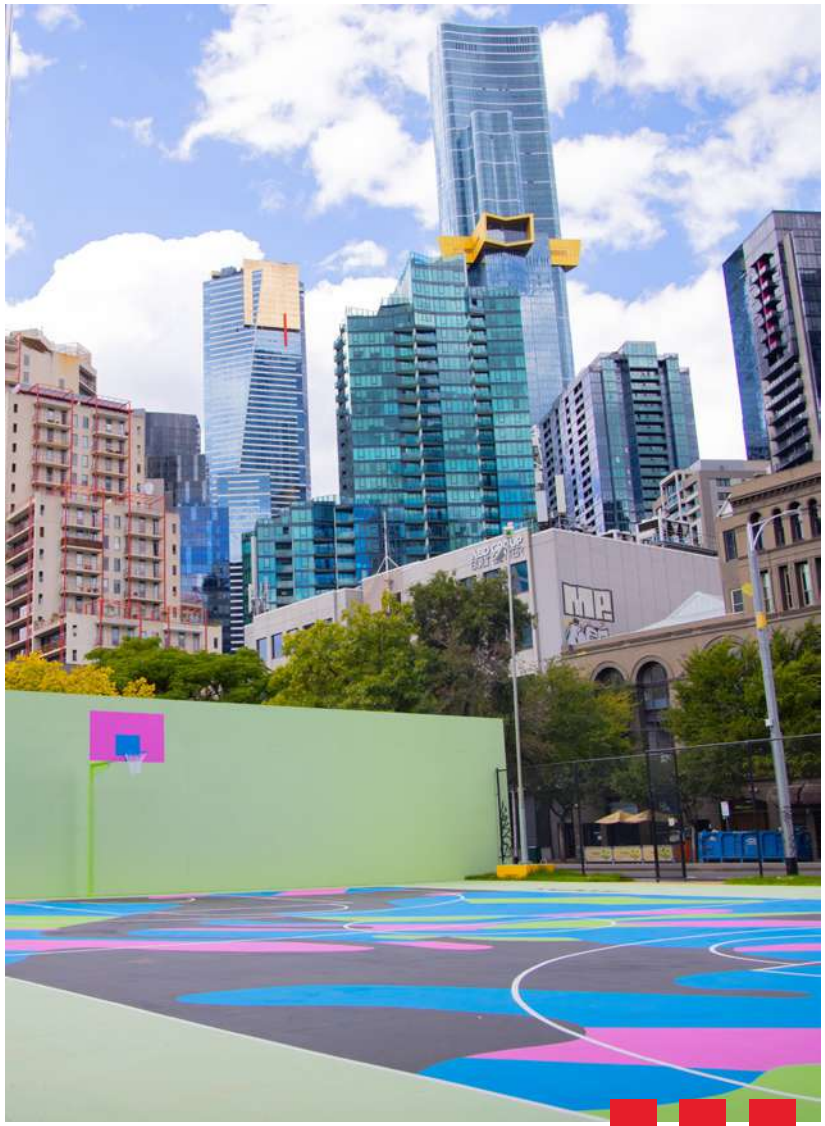
To position Melbourne as a leader within digital supply chains, companies need to embrace their own digital transformation journey. To achieve this, companies need to upskill their current workforce with the appropriate digital skills to maximise outputs from these emerging technologies and mitigate against risk.

Additionally, the government should work towards identifying the job areas in skill deficits (such as blockchain, AI and IoT) and promote/offer incentives around education to support the industry.

Recommendation 6: Develop a blockchain pilot for a Victorian supply chain

As outlined within this report, blockchain technology in combination with other emerging technologies, has a myriad of benefits and can create more efficient, effective and resilient supply chains.

It is recommended that the Victorian Government creates a blockchain based supply chain pilot for one of the industries. The construction industry, as highlighted in Case Study Two, is a great example of an industry that would benefit from blockchain based supply chains.



Conclusion

Conclusion

The Digital CBD research project forms the basis of this report which is the third in a series of five.

This series unpacks the opportunities and research required to develop a digital CBD in the key areas of rejuvenating regions, digital skills, digital infrastructure and securing supply chains – which has been the focus of this report.

Just and resilient supply chains are fundamental to the development of a digital CBD. But in order to build digital cities, digital supply chains need to be built first.

During the pandemic, businesses struggled with both demand and supply uncertainties which exposed vulnerabilities across both local and global supply chains. With supply chains and cities being economically interrelated, both encountered the same set of challenges.

This report highlights how rapidly accelerated technology adoption combined with the COVID-19 pandemic radically changed the way supply chains and cities now operate.

Technologies in the Web3 space are explored in order to address supply chain challenges and cybersecurity risks within the context of a CBD.

This cluster of Web3 technology includes blockchain and smart contracts, NFTs, verifiable credentials, TradeTech, IoT and smart sensors, autonomous vehicles and robotics, drones and AI/ML.

Examples have been provided to explain how this technology can be used to build secure digital supply networks that can reduce information asymmetries and enhance collaboration, agility and optimisation, whilst embedding just and fairer practices into digital processes.

And finally, it is argued that for business to fully leverage the unlimited potential of these technologies and build more resilient supply chains, they need more support from the government.

Therefore, a number of recommendations are proposed for implementation in order to build more resilient and just supply chains towards a digital CBD.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