

RE-THINKING AGRICULTURAL SUPPLY CHAINS IN NORTHERN AUSTRALIA

Hurriyet Babacan*

Rural Economies Centre of Excellence, James Cook University, Smithfield QLD 4878, Australia. Email: Hurriyet.babacan@jcu.edu.au

Ms. Jennifer McHugh

The Cairns Institute, James Cook University, Smithfield QLD 4878, Australia. Email: jennifer.mchugh1@jcu.edu.au

*Corresponding Author

ABSTRACT: Realizing the potential for growth and capitalizing on opportunities for Northern Australia requires effective supply chain networks. Agriculture is an important sector in the Northern Australian economy with significant production capabilities and the potential for creating national economic benefits. Northern Australia's fundamental supply chain deficiency constitutes the key source of comparative disadvantage the region faces, despite its significant resources, people and locational advantages. Drawing on reviews of several previous studies, critical analysis of the current value chain situations and consultations with key stakeholders, this article argues that there is a need to re-thinking agricultural supply chains in Northern Australia. Several issues impeding the connectivity between production and market require systematic consideration, including the priorities for Northern agricultural development, integrated supply chain planning, workforce shortages and skills gaps, supply chain infrastructure, capitalizing on Asian market opportunities, transport and non-freight subsidies, east-west and north-south supply chain hubs and improved coordination and collaboration. Corona Virus Disease-2019 has had serious impacts across the supply chains; therefore, re-thinking supply chains is crucial as the business as usual approach is not sustainable. It is now a critical time to re-think supply chains to address the challenges of developing effective and resilient Northern supply chains to enhance agricultural expansion and boost the national economy.

KEYWORDS: Supply chains, Northern Australia, regional development, economic growth, COVID-19

ACKNOWLEDGEMENTS: We gratefully acknowledge the funding received for this research project from Cooperative Research Centre for Developing Northern Australia (CRCNA).

1. INTRODUCTION

The Australian Government is committed to the development of Northern Australia. *Our North, Our Future: White Paper on Developing Northern Australia* (Australian Government, 2015) identified the potential for diversifying the economy for a more prosperous Northern Australia. There are significant primary production capabilities, including livestock, agriculture and horticulture. Northern Australia's agricultural sector, in particular, is a significant contributor to the national economy with the annual value of agricultural production in the region exceeding \$7 billion in 2018 (PricewaterhouseCoopers (PWC), 2020, p. 10), constituting approximately 14% of Australia's agricultural production (Dale *et al.*, 2020, p. 8). Agricultural development and expansion are a vital part of developing Northern Australia through the intensification of cattle production, new irrigated and dryland cropping systems, timber and forest industry development and aquacultural and horticultural production.

Realizing the potential for growth and capitalizing on Northern Australia's agricultural opportunities requires strong and effective agricultural supply chains, appropriate infrastructure and effective logistics networks. However, as Ash and Watson (2018, p. 302) argue, while there are climatic and environmental constraints, "it is mainly factors associated with finances and investment planning, land tenure and property rights, management, skills, and supply chains which provide the critical challenges" in Northern Australia. Among the well-accepted challenges facing Northern Australia's economic growth, agricultural supply chain shortcomings play a pivotal role (Dale *et al.*, 2020; Babacan and Tremblay, 2020). Given the current rapid changes in trading, technology, consumer and natural resource environments, and particularly in light of the impacts of Corona Virus Disease-2019 (COVID-19), supply chains are critical in maintaining the overall competitiveness of Northern Australian industries. The Australian Logistics Council (ALC) estimates that for every 1% increase in efficiency gained in the supply chain sector, GDP will be boosted by \$2 million (Australian Logistics Council, 2016, p. 3). With Northern Australia constituting approximately 12% of Australia's GDP, equivalent to \$187 billion in 2016-17 (Dale *et al.*, 2020, p. 8), there are significant gains to be made from supply chain efficiencies.

Drawing on work undertaken in Northern Australia, across several research projects and consultations with critical stakeholders, this article visits some of the key challenges in agricultural supply chains, reviews the key characteristics of agricultural supply chains, highlights the major supply chain challenges and identifies key areas in which a re-think of

supply chains is needed to bring about reliable, affordable, stronger and resilient agricultural supply chain networks across Northern Australia.

2. CHARACTERISTICS OF AGRICULTURAL SUPPLY CHAINS IN NORTHERN AUSTRALIA

Agricultural supply chains in Northern Australia are dynamic and complex. They involve a diverse range of interconnected networks of organisations. Higgins *et al.*, (2015, p. 341) point out that “despite the longevity, scale and importance of agricultural industries in Australia, supply chains are usually characterised by high transport costs along rural roads, seasonal constraints on usability, infrastructure distant from areas of production, and significant vulnerability to market- and weather-related shocks.” There have been many studies funded by the Cooperative Research Centre for Developing Northern Australia (CRCNA) during 2018-2020 in beef, aquaculture, horticulture, sugar cane, broad acre and timber products. These studies explore the key supply chain strengths and barriers. While the scope of this paper does not permit a deep drill into each commodity, specific commodities have individual unique supply chain barriers and strengths. This section summarizes the characteristics of supply chains that are applicable across a range of commodities.

The *strengths* of supply chains in Northern Australia include mature industries (e.g. beef, sugar, mangoes, broad acre crops) and emerging industries (e.g. aquaculture, avocados). Their strengths include a strong global and domestic demand; strong provenance, certification and traceability coupled with the ‘green, clean’ image of produce; low production inputs; well-established transport routes in some locations, particularly to southern domestic markets or transfer points for export; capacity for export and expansion due to availability of land and water options; and availability of research and development to enhance production (Babacan and Tremblay, 2020; ACIL Allen, 2020; KPMG, Premise and AEC, 2019; KPMG and Advance Crains, 2020; The Australian Trade and Investment Commission, 2015).

The *challenges* of supply chains in Northern Australia are often well understood and clearly identified. The main issue that emerges is the vast geographic footprint and freight costs for many commodities, from production processing to markets often requires transport distances of between 2,500 – 4,000kms (Higgins *et al.*, 2015, p. 32). Significant proportions of Northern Australia’s agricultural market are solely reliant on roads for freight (Reed, 2017; Babacan and Tremblay, 2020). The quality of road links across Northern Australia is varied with large portions

of the roads in Western Australia (WA), Northern Territory (NT) and inland Queensland being unsealed. Climate conditions challenge road reliability, especially during floods and other natural disasters and are the main source of uncertainty for the delivery of many key commodities, commonly resulting in time delays in getting products to market, excessive freight costs and therefore, affordability for the consumer. Direct costs of freight and the task of transporting goods is a major factor in enterprise profitability. Freight costs vary between 35% (Higgins *et al.*, 2015, p. 32) and 48.5% of farm gate prices (PWC, 2020, p. 37), depending on the commodity and the destination of produce.

Challenges of access to the sea, air, rail and road transport are articulated as inhibitors for agricultural expansion. Lack of adequate storage facilities at airports and ports, particularly cold storage and refrigerated freight containers, has been prohibitive for certain markets and commodities, especially those with perishable products. High operating costs of energy, lack of processing and packaging facilities, ageing infrastructure, bio-security challenges and lack of and other digital connectivity have also been highlighted by stakeholders and studies. Additionally, attracting and retaining an appropriately qualified workforce are major challenges. While producers may wish to enhance their exporting capacity, lack of access and knowledge to the overseas market, particularly in Asia, is a significant constraint. Lack of coordination across and within industries and cross-jurisdictional governance issues also pose additional challenges and reduce opportunities (ACIL Allen, 2020; KPMG and Advanced Cairns, 2020; KPMG, Premise and AEC, 2019; PWC, 2020).

Despite inefficiencies, some current supply chain patterns and linkages are well established across Northern Australia. Individual producers have had no option but to develop bespoke, 'fit for purpose' supply chains driven by managing risk/uncertainty, production cycles and weather conditions. The commercial realities facing individual producers drive agricultural supply chain behaviour and provide limited incentives for scaling production and collaboration. For example, in the context of Queensland, Hall and Frew (2017) suggest that "these specific conditions make arranging efficient large scale transportation difficult... and this creates gaps in knowledge of what is moving where and when... In turn, this leads to less efficient supply chains and constrains the ability of the sector to move its produce at the lowest possible cost." Southern focused transport infrastructure investments in the past, particularly road and rail infrastructure, have reinforced the funnelling of supply chains via southern routes and cemented Northern Australia's connections with and perhaps dependency on southern networks. Despite the products ultimately being

northbound, much of the produce goes through supply chain networks into southern Australia. This reliance is at the expense of improving northbound trade and gateways (shipping and aviation) and the possibility that strengthening and redirecting east-west routes could lead to more efficient freight solutions for Northern Australia.

Northern Australia's fundamental supply chain deficiencies constitute the key source of comparative disadvantage the region faces, despite its significant resources, people and locational advantages. The ability to attract investment and expand agricultural production across Northern Australia will require addressing these fundamental supply chain challenges. Supply chains specific to commodity or industry work with differing degrees of effectiveness, depending on the commodity and target market (e.g. domestic or export). In a recent research study on supply chains across Northern Australia, Babacan and Tremblay (2020) identified that stakeholders believe 'business as usual' is not sustainable in the long term and dramatically limits any possibilities for growth. Re-thinking supply chains is fundamental to the improvement of competitiveness, productivity and sustainability of Northern Australia.

3. RE-THINKING AGRICULTURAL SUPPLY CHAINS IN NORTHERN AUSTRALIA: KEY DIMENSIONS

Stakeholder insights are critical in understanding the layered and multifaceted aspects of re-thinking supply chains. The authors have been working across Northern Australia over the last three years and have been involved in and led numerous research projects, forums, and consultations with diverse stakeholders. Many research projects are specifically relevant to understanding the dimensions of re-thinking agricultural supply chains. These projects included interviews with 25 stakeholders and two major roundtables (with over 85 organisations); rural and regional workforce policy research with 30 stakeholder interviews; two regional connectivity research projects focusing on agricultural industries (over 100 stakeholders in focus groups and workshops); and regional economic development policy research (27 interviews). These projects were undertaken between 2018 and 2020 using mixed methodologies and appropriate ethical clearances were obtained for each research project. This section draws data from these research projects and explores the main considerations for shifting supply chain thinking to ensure effective and resilient supply chain networks across Northern Australia.

Vision for Agricultural Development and Supply Chains in Northern Australia

The Australian Government's White Paper on Northern Australia development (Australian Government, 2015) and Agricultural Competitiveness (Commonwealth of Australia, 2015), provided a framework for agricultural development. Agricultural development takes place within a complex set of fragmented industries and cross-jurisdictional strategies and actions (Babacan and Dale, 2019). Critical areas such as water allocation, vegetation and land use planning, tenure security, environmental standards, biosecurity, regulatory approvals, infrastructure development, workforce planning and managing risks for investment attractiveness take place without a united or concise vision. Although there are many initiatives for agricultural development in Northern Australia, they tend to occur without a focused and/or shared planning and strategies, resulting in the fragmentation of joint efforts for investment and outcomes and loss of opportunities (Dale *et al.*, 2020; PWC, 2020).

Absence of a focused vision for agricultural development results in a lack of agreed supply chain development prioritisation. Supply chain priorities may be arranged on regional, sector or market (demand) considerations. Stakeholders identified that supply chain initiatives are largely enterprise or individual commodity driven without a coordination mechanism within and across industries or government. Stakeholders voiced the need to develop supply chain priorities and integrated supply chain planning for Northern Australia, particularly in a post-COVID-19 environment, based on agricultural development priorities, domestic and global demand and markets and supply chain potential. These focused priorities will need to consider agricultural supply chain opportunities, infrastructure investments, international market links and support for supply chain development areas where scale and value can be demonstrated. Consideration needs to be given to east-west links across Northern Australia rather than just north-south links. This might entail deliberately attempting to disrupt some of the north-south road-based freight flows and using different policy principles to guide and encourage investments.

Transport Costs and Freight Subsidy for Northern Australia

The idea of a freight subsidy for agriculture was raised by a range of stakeholders, particularly in the context of addressing competitive disadvantage caused by the cost of transport. The transport options for

Northern Australia span across all major modes of transport, including sea, air, road and rail. There are 80 airports, 25 ports with commodity-specific rail routes (particularly bulk minerals) and a range of transport and road routes such as Darwin to Adelaide, North Coast line system in Queensland and an extensive network of sealed and unsealed roads. All the transport options mentioned above have challenges. Airfreight options are inadequate and costly, particularly due to lack of carriers, low international air freight volumes, lack of wide-body passenger aircraft, and insufficient refrigerated container capability which limit the export of high-quality/high-value agricultural products from the region. Each sea port has its unique challenges depending on the port's natural characteristics, channel depth for vessel entry, capability of vessels and terminal area and specialised port infrastructure (for storage, refrigeration, handling and stockpiling). Key challenges exist in the rail freight system with no national consistency around rail gauges or axle load limits, affecting the efficiency of general freight and bulk commodity movements (Commonwealth of Australia, 2016, p. 5).

The Northern Australia road network is extensive and characterised by long-isolated and often unsealed roads with low daily traffic volumes and major national highways. Due to limited options in some industries, there is significant over-reliance on road networks, such as the cattle industry (Reed, 2017; Tremblay *et al.*, 2020; Babacan and Tremblay, 2020). The level of service the road network can provide is impacted by a number of factors, including the climate (wet and dry seasons), levels of economic activity and the configuration of the road, e.g. sealed, unsealed, weight restrictions (Infrastructure Australia, 2015).

In response to the challenges mentioned above, stakeholders raised the consideration of an agricultural freight subsidy for Northern Australia. A subsidy is defined as any form of government support provided to producers or consumers (Riley, 2020). It is economic assistance that is granted directly or indirectly. There are precedents in Australia for freight subsidies in addressing supply chain competitive disadvantage. For example, the 1989 *Tasmanian Wheat Freight Subsidy Scheme (TWFS)* was established to subsidise the cost of bulk shipments of wheat from the mainland to Tasmania by sea. The introduction of the *TWFS* coincided with the deregulation of the Australian domestic wheat market and replaced a wheat freight levy that had existed since 1959. *The Tasmanian Freight Equalisation Scheme (TFES)* was introduced in 1976 (Productivity Commission, 2006). The key motivations for establishing the scheme were addressing disadvantage for producers who rely on shipping across the Bass Strait as shipping can cost more than double the cost of road transport

for a similar distance to the mainland; therefore, curbing geographical disadvantage and achieving overall regional economic development objectives (Productivity Commission, 2006). These arguments have relevance and precedence to the development challenges in Northern Australia.

There are mixed views among economists and policymakers about the effects and impacts of subsidies applied to support specific industries or sectors. The key benefits of a subsidy include enabling industries/enterprises to respond to problematic situations; reducing production and input cost; providing encouragement and incentive to develop more efficient and innovative production and distribution processes; correcting imperfections or failures in the market and facilitating market adjustments; reducing risk and leveraging the subsidy to attract private sector investment while providing safeguards for the return on investment. The disadvantages of a subsidy may include: market distortion effects (e.g. competition, price, demand and supply levels, reduction in entrepreneurship); creating dependency on a subsidy by industry/enterprise and continue inefficient production processes; consolidating particular types of enterprises and excluding others; contradicting international agreements; increased transaction and administrative costs to the government; and social equity concerns about public expenditure supporting private gains and the cost of public investment in freight may lead to a reduction in expenditures in other areas potentially resulting in social net welfare loss (Li *et al.*, 2018; Simpson and Clifton, 2016; Mitra and Webster, 2008; Bartik, 2005; Baum, 1987). As economists have long debated the merit of subsidies as a policy mechanism, the importance of keeping a long term perspective on the costs and benefits derived from subsidy interventions is critical in policy deliberations (Baum, 1987).

Insights from stakeholders demonstrated support for an agricultural subsidy, with some arguing for a freight while others suggested non-freight areas for a subsidy. Subsidy benefits were seen mainly in three key areas: i) leveraging the subsidy for much-needed capital investment attraction, ii) meeting regional development aspirations, particularly for building competitive and resilient regions, and iii) addressing areas of significant market failure or thin markets, enabling industries to respond to specific problems and addressing the higher cost of production in Northern Australia. Stakeholders who did not support a freight subsidy identified a range of challenges, including better articulation for the purpose of the subsidy, what problem the subsidy will address, what time frame the subsidy will run for, and the cost-benefit analysis of the subsidy as an

investment against other options. Other stakeholders argued for alignment of the subsidy with government, industry and community priorities. Some argued that subsidies may be utilised to encourage/discourage particular producers' behaviours towards sustainability and resilience in the long term.

Those favoured a non-freight related subsidy put forward ideas including a time-limited subsidy for strengthening supply reliability and intensification in specific products; developing a regional-hub and spoke model of supply chains within Northern Australia and developing east-west supply chain network; improving the import-export connection. Subsidies for areas in which there were market failure associated with agriculture were also supported, e.g. infrastructure including freight infrastructure, digital connectivity and energy, with the view that this may provide longer term sustainability benefits and value-adding options to their products.

Strongly emerging from the research is the need to explore the type of investment that is required to strengthen agricultural supply chain networks and whether a subsidy is needed and if so, what subsidy-type is relevant to achieve focused outcomes? It is clear that more detailed work is required to identify the priorities, industries, issues/problems and time frames as well as modelling of the costs and benefits is needed. Adopting a subsidy will require a clear strategy specifically targeted to shifting outcomes and productivity from existing to a more significant scale. As such, it is critical to have comprehensive data and market analytics; a shared vision for market/industry direction; identify which problems are being addressed by the subsidy; modelling to show the impact of the intervention against economic and regional development objectives; and a realistic assessment of direct and indirect costs and benefits across beneficiaries (Babacan and Tremblay, 2020; Simpson and Clifton, 2016).

Supply Chain Infrastructure

The *Industry Innovation and Competitiveness Agenda*, (Commonwealth of Australia, 2014) identified infrastructure as being fundamental to Australia's competitiveness. The Australian Transport and Infrastructure Council released Australia's first *National Freight and Supply Chain Strategy* in 2019, where infrastructure is noted as one of the four priority areas. The strategy acknowledged that ensuring the development of a comprehensive 'infrastructure investment framework' was a necessity in order for domestic and international supply chains to be serviced by resilient and efficient key freight corridors, precincts and assets; provide

regional and remote Australia with the infrastructure capability to connect regions and communities to major gateways, through land links, regional airports or coastal shipping; support the development of digital infrastructure and communication services necessary and to future-proof new infrastructure (Transport and Infrastructure Council, 2019). Northern Australia's critical infrastructure challenges fall within four characteristics:

- *Demand gaps* for infrastructure where demand exceeds capacity, or approaches capacity such that transport becomes congested, unreliable, unsafe, or where capacity is inadequate for larger, reliable and more efficient services;
- *Opportunity gaps*, where the provision of improved or lower-cost infrastructure could generate demand that is not currently present, stimulating economic development or population growth;
- *Cost gaps*, where the cost of providing infrastructure is higher than in other locations or facilities, due to economies of scale differences or other factors, limiting or deterring economic development activity; and
- *Service standard gaps*, where the level of infrastructure service falls short of community, policy-based or legislated standards for attributes such as safety, availability and quality (Infrastructure Australia, 2015:15).

Much of Northern Australia can be classified as rural, regional and remote. Infrastructure Australia (2020, p. 187) notes that developments in the economy, regulation, technology and service delivery mean Australian infrastructure needs are changing, leaving some regional centres at risk of being left behind. Lags in infrastructure quality and access to services in smaller cities and regional centres lead to a growing gap in productivity and liveability relative to larger cities. These lags have direct impacts on supply chains. A number of recent regional studies in Northern Australia identified significant agricultural supply chain infrastructure needs and concluded that infrastructure for priority products was inefficient or underdeveloped (Dale *et al.*, 2020; ACIL Allen, 2020; KPMG, Premise and AEC, 2019; KPMG and Advance Crains, 2020). Stakeholders identified a range of infrastructure gaps in supply chains in Northern Australia, including roads: access, condition, upgrades, bridges and networks; aviation: routes, hubs, storage and refrigeration; ports: access to infrastructure that can enable multi-modal use, cold chains; rail: interoperability, rail gauges or axle load limits and routes; digital connectivity, communications, internet access and affordability, mobile connections and black spots; power: cost of energy and access to power;

water: water access for irrigation, water supply; and distribution, storage, packaging and processing hubs.

There is increasingly a recognition of the problematic nature of infrastructure planning and investment in Northern Australia. For example, Dale *et al.*, (2020, p. 31) state that, “some of the region’s supply chain infrastructure for priority products is underdeveloped or inefficient.” Infrastructure Australia (2020) argues that there are ‘sources of market failure’ in infrastructure delivery that require a government response. The sources of market failure include a limited economic scale in many infrastructure settings, resulting in a high cost and/or poor quality of service, an absence of competition in service provision, ‘first mover disadvantage’ and a lack of coordination precluding more extensive networks. Greater level of coordination is required to provide more reliable and lower cost service; and greater capacity to pay for infrastructure services (Infrastructure Australia, 2015, p. 5). For remote and rural towns and cities, infrastructure challenges include high construction cost, lack of compelling economic justification for investment, exposure to climate and weather events and reliance on a single asset and network with an increased likelihood of asset failure (Infrastructure Australia, 2020).

The lack of consistency across jurisdictions in infrastructure planning and investment impacts continuity and efficiency levels in the supply chain networks (KPMG and Advance Crains, 2020; Dale *et al.*, 2020). There are significant differences between jurisdictions in their level of privatisation, preparedness and capacity to embark on large new infrastructure programs and funding flexibility. The views from participants are supported by research studies that indicate that there is no consolidated understanding of investment requirements in Northern Australia which hinders potential foreign investments leading to investor uncertainty and increasing level of risk (PWC, 2020; Dale *et al.*, 2020). Infrastructure Australia (2020, p. 193) concludes that the lack of coordination, planning and investment across jurisdictions in Northern Australia has resulted in disconnected transport and energy networks and inefficient supply chains. The use of infrastructure across Northern Australia can be seasonal with high demand at particular points of the year, such as harvesting time. Boom and bust cycles, cyclical nature of demand and seasonal variations should be considered for much more resilient and adaptive infrastructure (Infrastructure Australia, 2020). Northern Australia’s infrastructure needs fit into many categories outlined in the Australian Government’s ‘Infrastructure Priority List’, namely, asset renewal, corridor preservation, efficient markets, the opportunity for growth, remote infrastructure,

resilience, road safety and social infrastructure (Infrastructure Australia, 2020).

Stakeholders raised concerns about the way infrastructure decisions are made, with key issues highlighted, including a lack of place-based considerations. The approaches taken for infrastructure development place cost and population base, i.e. using economies of scales approach, as central. These approaches were seen to be too narrow, without broader social, economic and sustainability considerations. Some argued that such analysis favoured metropolitan areas which are more densely populated and advocated that future assessments should be modelled on the whole of a supply chain with consideration of longer-term and more comprehensive economic and social benefits. It was further pointed out that the broader approaches would be better aligned with the stated government's priorities, such as regional development and decentralization outcomes. This proposition is supported by the academic literature. For example, Stank *et al.*, (2015:19) argues that there is a need to move from managerial accounting in supply chains to a total value orientation, being guided by overall value creation rather than costs being the main driver. Lack of engagement of key local/regional stakeholders in identifying needs, lack of evidence of infrastructure needs and options, fragmentation in infrastructure planning and decision making, the lack of liveability considerations in infrastructure planning were other serious considerations identified by stakeholders. The need for cross-sectoral and multi-use infrastructure and the lack of private sector investment were also noted. Participants reflected on the utilisation of existing infrastructure and supported the exploration of sharing options between public and private sectors in the North and the need to enhance existing infrastructure rather than creating new ones e.g. remote community airports and airstrips for multi-sector and community use.

A number of stakeholders also commented on the narrow definitions of supply chain and industry infrastructure. It was pointed out that supply chain infrastructure should not be thought of separately from other infrastructure across Northern Australia. The stakeholder noted that due to geographical conditions, agricultural supply chain resilience was linked with broader communities and regional resilience and growth. For that reason, supply chain infrastructure needs to consider liveability and community infrastructure to facilitate consumer demand, to attract workers to the regions, build community and ensure resilient supply chains in Northern Australia.

Some reviews regarding infrastructure planning and decision making reflect the feedback from stakeholders. There is evidence of fragmentation,

including the lack of prioritisation of existing infrastructure, project feasibility, development and evaluation processes, duplication and lack of coordination (Productivity Commission, 2014; Infrastructure Australia, 2015; Australian Logistics Council, 2016). The Productivity Commission (2014) argued that there is a need to overhaul the processes for assessing and developing public infrastructure in Australia, much of it relevant to Northern Australia. The Productivity Commission (2014, p. 2) called for a reform in governance and institutional arrangements for public infrastructure for better decision making in project selection, transparent cost-benefit analysis, risk analysis, financing and delivery of services from new and existing infrastructure. Infrastructure Australia (2015, p. 26) posits that strengthened infrastructure network, planning and coordination merit consideration to help lower the costs of infrastructure service and improve the reliability of supply.

Infrastructure needs vary across sectors in Northern Australia. The common outcomes sought from infrastructure are resilience, adaptability, reliability and efficiency (Infrastructure Australia, 2020). Stakeholders argued for a “more targeted supply chain infrastructure investment.” However, studies indicate that there is no consolidated understanding of investment requirements in Northern Australia, hindering potential foreign investments and leading to investor uncertainty and increasing level of risk (PWC, 2020; Dale *et al.*, 2020). This further emphasises the need to re-think and adopt alternative pan-northern and regional frameworks for the assessment of future infrastructure investment, particularly based on agricultural development. Additionally, there is also a need for improved mechanisms for supply chain infrastructure feasibility assessments and coordinated finance/investment attraction efforts across jurisdictions and industries in Northern Australia.

Coordination and Collaboration

The supply chain networks across Northern Australia is a complex system of organisations including producers, peak industry bodies, regional development bodies, the three levels of government, and other stakeholders. Collaboration and coordination within and across industries, as well as across jurisdictions is a difficult task. There are some attempts to integrate Commonwealth, State and Territory Government efforts such as the Northern Australian Strategic Partnership, the Northern Australian Ministerial Forum and the Northern Australian Advisory Group. These initiatives aim to drive integrated approaches to the development of Northern Australia. The CRCNA argues that “the identification and

resolution of higher-level policy thinking and the development of coordinated cross-jurisdictional responses will be important for the future of Northern Australia” (Dale *et al.*, 2020, p. 32). The landscape of regional governance is one of the ‘crowded’ systems of regional, state and national structures, some with an ambiguity of roles and responsibilities at different levels of government (Babacan and Dale, 2019). This is confirmed by the Productivity Commission’s work on regional development reporting that “there is significant confusion, overlap and unhealthy competition between the Australian, State, Territory, and local governments in the pursuit of regional development... These issues are made more challenging by inadequacies in the institutional and governance arrangements that limit the effectiveness of planning and expenditure in regions with respect to transition and development” (Productivity Commission 2017, p. 163).

While some of the initiatives aim for integration at a higher level, the literature and our consultations identified that there is a lack of a common vision and significant fragmentation (Dale *et al.*, 2020; Babacan *et al.*, 2020). Fragmentation in coordination occurs in three ways. Firstly, there is a lack of collaboration and coordination within the same industry. Secondly, there is a lack of collaboration and coordination across multiple industries, which may have supply chain synergies. The third area is the lack of cross-jurisdictional coordination, both across the three tiers of government and industries (Dale *et al.*, 2020; Babacan and Dale, 2019; Akbar *et al.*, 2019).

Stakeholders identified a range of collaboration and coordination challenges. These included contradictory actions at the industry, policy or regional level; duplication of efforts, infrastructure and training; lack of awareness of what others in the region are doing; lack of potential cost savings and efficiencies as a result of joint initiatives and resource sharing; lack of scale or volume as industries are working alone; contradictory policy interventions; excessive red tape and regulation; lack of joint vision; inability to produce multiple commodities; lack of coordination mechanisms, lack of leadership; and lack of joint advocacy and a unified voice. The views of stakeholders are echoed by national peak bodies of industries. For example, in the context of freight, the fragmentation is recognised by the Transport and Infrastructure Council (2019:16). The Council acknowledges that the freight sector has suffered from inconsistent decision-making, lack of certainty and inconsistent rules (e.g. managing fatigue, drug and alcohol use, speed zoning), causing confusion, duplication and increased costs for operators. Stakeholders have identified the need to develop a robust and transparent end-to-end supply chain

governance framework for Northern Australia (Transport and Infrastructure Council, 2019).

Stakeholders provided diverse views about the types of collaborations that were needed. Some identified that it was important to take a sector-by-sector approach, achieving intra-sectoral collaboration outcomes as a more manageable approach. Others recognized that there were synergies across sectors and the major challenges were cross-cutting themes, which could be more effectively addressed by a multi-sectoral approach (Babacan *et al.*, 2020). The research and data on collaboration across sectors are limited. One study identified that a lack of coordination through the supply chains between growers, processors, marketers and transporters is the main impediment to exporting perishable commodities to Asian markets (Akbar *et al.*, 2019). In a study of horizontal collaboration within the mango industry in Central Queensland, it was identified that there are limited collaboration among farmers and the other actors involved in the exports of perishable commodities into the Asian markets (Akbar *et al.*, 2019, p. 23). Participants also identified that the benefits of collaboration on achieving supply volumes, collaborative activities such as communication, information sharing, production inputs, market access and demand, price setting, risk sharing and profit sharing as well as marketing benefits such as clean-green motto, global brand development, traceability and quality control.

In a supply chain landscape of multiple agencies and stakeholders, participants stated that there is no coordinating mechanism for supply chains in Northern Australia (Dale *et al.*, 2020). There were a gap in the supply chain architecture for Northern Australia and the absence of a strategic and coordinated supply chain plan. Many agencies identified that they did not have either the mandate or the resources to undertake a supply chain coordination function and could not determine who could take the leadership (Babacan *et al.*, 2020; Akbar *et al.*, 2019). Stakeholders identified the need for a stronger place-based and leadership-rich supply chain partnerships, pan-Northern Australian cross-sectoral supply chain integrative mechanisms for coordination and coordination on cross-cutting policy and program supply chain issues.

The re-thinking about supply chain collaboration, integration and coordination needs to be at different levels:

- At place or sub-regional scale. This is linked with collaboration within sectors but also across different sectors in regional economic and agricultural development planning;
- Sectoral, horizontal collaboration, within specific sectors across Northern Australia;

- Multi-sectoral level, cutting across different sectors, at different scales;
- Across the jurisdictions that constitute Northern Australia, for harmonized approaches;
- Pan-Northern Australia integration, for overarching issues that are cross-cutting such as de-risking, infrastructure feasibility and coordinated finance; and
- Global and sub-regional trading blocs with neighbouring countries. (Babacan *et al.*, 2020; Dale *et al.*, 2020; Akbar *et al.*, 2019).

The challenge ahead is to invest more strategically at different scales of coordination to achieve a better understanding of supply chain potential and targeted investment in key supply chain collaboration. Developing integrated approaches that enable the development of a shared vision, strategic planning, prioritisation and coordinated action across industries, governments and communities towards identified priorities will be fundamental in achieving significant impact. These integrated approaches will require a re-think about supply chain coordination architecture and governance arrangements. In a review of megatrends that revolutionise supply chains, Stank *et al.*, (2015) introduced the idea of ‘vested’ relationships to achieve win-win outcomes for all. The focus is on ensuring long-term success for all parties by developing operational and strategic plans detailing joint rewards. Vested relationships also require mutual accountability if they are to be successful. The ultimate goal is to optimize total system value creation (Stank *et al.*, 2015, p. 15).

Workforce Considerations

The economies of Northern Australia are dynamic and are economies in transition with structural adjustment due to increasing and rapid exposure to global markets, deregulation, withdrawal of industry protection measures, fluctuating terms of trade, impacts of technological change, environmental concerns and changing consumer demand. The regions, industries, and enterprises are all being affected by industry transition with varying “speed, magnitude and severity” across different industries (Jobs Queensland, 2018, p. 7). These transitions, likewise, impact on the workforce-skills, gaps and shortages (Productivity Commission, 2017; Wibrow and Circelli, 2016; Beer, 2015).

Stakeholders identified workforce gaps, skills shortages and lack of staff with experience and qualifications in areas linked with digital technologies and management. The specific issues that was outlined by stakeholders

included difficulty of attracting staff to regional areas, liveability considerations, the lack of access to education and training options, lack of career promotion and progression, limited employer capacity for recruitment in small businesses, lack of attractiveness of industry, an ageing workforce, negative perceptions of young people towards supply chain and agricultural industries, and boom and bust cycles in regional areas reducing the availability of skilled workers who could earn more in mineral industries. Stakeholders suggested that education providers have a critical role to play in supporting the workforce development needs of both agricultural development and supply chains sector in Northern Australia. Stakeholders reported a mismatch between labour market needs and what education providers offer, including a lack of micro skilling. It was argued that there needed to be better engagement between education providers and industry and agility on behalf of educational institutions to respond to industry needs. Some argued that the nature of degree and vocational/training programs was cumbersome and could not be altered quickly.

Many stakeholders identified the barriers to education in Northern Australia and lower levels of higher education qualifications. A more recent trend has been a decrease in vocational enrolments. Enrolments in the Transport Logistics Training Packages have decreased, across the nation, by 51% over the last four years, for occupations involved in warehousing and logistics operations, operations freight handler, mobile crane operations, waste driving operations, materiel and deployment logistics, traffic operations, bus and coach operations and customs broking (Australian Industry Standards (AIS), 2019, p. 15). There is a tendency for programs and training to be demand-driven and therefore unsuitable for smaller or lesser known industries and regional areas. The reduction of training and apprenticeship opportunities by governments industries and local government also reduced the staffing pool. The fly-in-fly-out workforce (FIFO) was seen as problematic for a range of reasons, including major impacts on the employee and their families, lack of integration with the local community, strain on regional infrastructure, lack of sustainability for the industry (due to worker burnout) and leakage from the local economy of wages (Babacan and Tremblay, 2020).

The supply chain workforce, across different sub-sectors, is expected to grow between 2-6 % in Northern Australia (Deloitte Access Economics, 2018). Stakeholders recognized technological innovations will continue to disrupt the supply chain industry at a rapid pace and provide opportunities and challenges. The new industrial revolution, incorporating complex computerised systems, data and software to create 'smart' processes and

products are significantly altering the skills required. Significant changes to the industry will require workforce skills in new technological innovations such as robotics, machine learning, internet of things and cloud technology; big data use; telematics; cyber security, digital customer communication for online, 24 hour per day methods of supply and technologies around traceability and visibility of products (AIS, 2019). In addition to the digital technologies skills, the industry survey has also identified the need for ‘soft skills’ such as leadership, management, teamwork, problem solving, critical thinking, communication, and innovation (AIS, 2019).

A survey of employers in Northern Australia by the Department of Employment in 2016 demonstrated difficulties in recruitment across different sub-regions. The following table shows the difficulties experienced by employers in recruitment across different spatial locations in Northern Australia:

Table 1. Employer Difficulties in Recruitment across Northern Australia.
Source: Department of Employment (2016).

Location	% of employers experiencing recruitment difficulties
Darwin	63%
Outback Queensland	59%
Kimberley	54%
Outback Northern Territory	43%
Rockhampton	33%
Pilbara	32%
Cairns	30%
Townsville	39%
Mackay	21%

This trend in recruitment is also reflected in the transport and supply chain industries, an industry that is a vital part of supply chains in Australia. The Transport and Infrastructure Council (2019, p. 17) points out that “the Australian freight sector is having difficulties in attracting skilled workers across its various functions - including logistics, quality control, warehousing and trade negotiations”. The Australian Industry Council surveyed the transport and logistics industry workforce needs between 2018 and 2019. Over 80% of employers in the industry reported experiencing skills shortages in the last 12 months. The occupations reported as being in shortage were heavy vehicle drivers, drivers (general),

educators, trainers and assessors, warehousing, and supervisors/managers (AIS, 2019, p. 27). The reason for the shortages was reported as ageing population and retirement of current staff; unattractive job prospects; poor industry image; cost and time to achieve the required qualification; competition from other organisations (within and outside the industry) and wages considered too low (AIS, 2019, p. 28).

Adaptive and resilient supply chains cannot occur unless human capability and workforce barriers are addressed. There is re-think required in the way pan-Northern Australia and sub-regional supply chain workforce planning is addressed. Developing strong career pathways, coordination of industries for strong labour market growth, building employer capacity to attract and retain and addressing liveability as part of supply chain infrastructure are critical considerations. Strong collaboration between industries and education providers is required to ensure that there is effective alignment between education providers and industry needs. Given the challenges of attracting and retaining workers in rural/regional areas and the lower levels of qualifications and barriers to access education, re-thinking needs to be given to upskilling and retraining the current and future workforce as a priority for Northern Australia to keep pace with future changes. Other options such as international migration, working visas and tapping into non-traditional workforce sources, such as women and students also require further investigation.

Capitalising on Opportunities in Asia

There is much discussion and appetite around the export opportunities in Asia, with 60% of global population growth predicted to be in Asia by 2030. In 2020, more than half the world's middle class will be from Asia and will demand high-quality food products (Austrade, 2015, p. 8). Austcham (2019) concluded that there is a large opportunity for accelerated export growth for Northern Australia in the agri-food sector in the Association of Southeast Asian Nations (ASEAN) due to population growth, rise of consuming middle class, rapid urbanisation, constraints on land available for agriculture and the promotion of clean and healthy food. Regional studies highlight the potential for growth in Northern Australia. For example, KPMG, Premise and AEC (2019) estimated that there is \$3 billion in unmet global market demand across ten of Australia's leading agricultural export destinations and identified five priority products: beef, avocado, macadamia, onshore aquaculture and soybean.

Many of the stakeholders believed that Asia holds the key to future agricultural industries in Northern Australia. However, some pointed out

that the focus on Asia has been discussed for a long time, but due to many factors, on the supply and demand side, these opportunities have not been effectively capitalised. Some of the barriers included lack of vision and prioritisation for agricultural expansion, lack of infrastructure, lack of air freight options, lack of cold chains, complexities of bio-security and certification, tariff and non-tariff barriers, lack of exporter/producer knowledge about Asian markets, lack of market information, biases about Asia, lack of understanding or knowledge around the relational side of the business and high-level transport costs. Products destined for the Asian markets are still being sent to cities in Southern Australia, dramatically increasing the distances the produces travels and impacting on emerging trends such as food miles. This is largely due to the lack of other affordable options for freight. The feedback from stakeholders is supported by the study conducted by Austcham ASEAN (2019), that highlights that despite progress due to free trade agreements, key gaps in the trade environment remain, including a lack of supporting trade infrastructure (e.g. cold storage facilities), regulatory bottlenecks (e.g. non-tariff measures, Foreign Direct Investment restrictions, lengthy red tape) and skills gaps.

There were numerous suggestions from stakeholders about seizing opportunities in the Asian markets. These ideas included a clearer vision and strategy for exporting; development of North Australian regional supply chain hubs with different transport options, infrastructure development around storage, processing and packaging, Asian market focused value adding, improved market intelligence and capacity building of producers. Developing value-adding capacity is a critical factor, ensuring that the products could be enriched to produce higher value returns. Value-adding is possible through hubs across Northern Australia or in Asia. Linkages with big agro-business hubs across Asia in places such as Thailand, Malaysia and Indonesia where supply chain synergies existed was an important suggestion. It was argued by stakeholders that supply chains in Asia faced similar challenges and that efficiencies could be gained by establishing supply chain hubs in partnership with Asian companies. Another was the idea of linking with close neighbours to Northern Australia such as Indonesia, Papua New Guinea (PNG), East Timor, and Fiji to achieve supply chain synergies and achieve demand and supply resilient higher value supply chains. The synergies include addressing joint areas of need such as supply chain workforce supply and training requirements, processing/packaging/storage options, focus on niche markets, the gateway to other markets post value adding processes and developing a sub-regional trading bloc for resilient supply chains. These suggestions go to the core of re-thinking how supply chains can

better focus on being more effective in taking advantage of the opportunities in Asia and the Pacific.

4. IMPACTS OF COVID-19

COVID-19 has introduced shocks to all aspect of economic and social life at a global level and has critically transformed the way we do business. The important role that supply chains play in our lives has been highlighted during this crisis, and the “supply chain has become a main protagonist everywhere” (Buatois, 2020). The impacts of this pandemic are expected to be unlike previous crises and that “this disruption has affected nearly all layers of supply chains – from manufacturing and distribution, through to delivery” (Bowden and Thorpe, 2020, p. 21).

The literature on the impacts of COVID-19 on agricultural supply and value chains highlights a mix of effects on business viability, with more severe impacts on the tourism, education, food and catering, retail and travel industries. This has flow-on effects on demand for agricultural produce as the food, tourism and catering industries have shrunk. Studies identify that the impacts of COVID-19 on agricultural supply chains include constraints on freight and logistics channels, access to imported inputs used in agricultural production, impacts on agricultural trade and export focused supply chains, changes to consumer demand due to income effects and access to labour (Greenville *et al.*, 2020; Department of Agriculture, Water and Environment, 2020; Organisation for Economic Co-operation and Development (OECD), 2020). The limits on mobility of people contribute to labour shortages and exacerbate skills gaps. For example, the Pacific Islands Seasonal Worker Scheme that provides valuable labour for farms during peak harvesting season was affected by the closure of international borders. Additionally, the pool of backpackers that contribute significantly at harvesting times has dramatically reduced. Other agricultural impacts include accumulation of surplus produce not being sold, putting pressure on storage facilities and resulting in losses of perishable commodities. In a global system, producers who are reliant on overseas products for production, parts, maintenance and other critical elements have had impacts on the availability of imports due to port closures or other freight restrictions. In many instances, panic buying has stretched supply chains and supply of products. One supermarket owner noted that “we didn’t have a supply issue; we had a demand issue” (stakeholder workshop). Consumer demand impacts are also echoed with consumers shifting from high-value products to more staple products and drop in consumption away from home due to restaurant and café closures

or social distancing measures. Additionally, the grounding of airlines has added to the cost of freight and lowered trade volumes (OECD, 2020; Deloitte, 2020).

Stakeholders identified a number of supply chain challenges in the context of COVID-19 in Northern Australia. Some of these include choke points and bottlenecks in supply chains, workforce shortages and challenges and production agility and communication to maintain consumer trust, safety and supply. Three critical areas of focus emerge during COVID-19 for supply chains in Northern Australia.

1. *Self-reliance* and removing single-source global dependencies for markets, input and materials. This requires re-thinking about new logistics domestic hubs that promote east-west connectivity, in addition to the north-south links that exist now. An examination to shifts to local production, localised and modular supply chains is also essential.
2. *Building resilient demand chains*. The volatility of demand for exports from Northern Australia and the ways to minimise the impacts of demand shocks provides opportunity for developing longer-term, more resilient demand chains.
3. *Developing resilient and adaptive supply chains* in Northern Australia in the face of global level shocks. Northern Australia's production systems are accustomed to shock, particularly arising from climatic conditions such as drought and floods and have evolved flexible production systems. The extent to which North Australia supply chains are flexible and adaptable is unknown and is identified as a critical research area. Key aspects include reliance on single/multi-sourced commodities and inputs; workforce, supply chain relationships; distribution networks; transport interoperability; interchangeability, alignment with other suppliers, and systems agility. Resilience in supply chains is identified as one of the major forces shaping Australia and will determine recovery from the pandemic (Bowden and Thorpe, 2020). Building resilient supply chain also results in competitive businesses that will be sustainable in the long term (Michelman, 2007).

5. CONCLUSION

The Australian Government is committed to the development of Northern Australia and sees it as a key contributor to Australian prosperity and development. Agriculture is one of the key industries of Northern Australia and has the potential to expand and grow. As noted by the CRCNA “the most significant challenge for the development of agriculture in the north, however, remains the under-development of higher value and more efficient, low impact agricultural ventures and supply chains, whether they be large or small in scale” (Dale *et al.*, 2020, p. 38). Realizing the potential for growth and capitalizing on agricultural opportunities for Northern Australia requires strong and effective supply chains, supply chain infrastructure and effective logistics networks.

Improved value creation across the supply chain cycle, agility, smart and integrated supply chains are going to be critical to Northern Australia. Supply chains are rapidly changing with increased emphasis on customer relationships, transparency of supply chains, adaptive capability, rapid technology growth, information sharing and utilisation, the integrated whole system approach, skills and knowledge of employees, and measurement of overall value management rather than specific metrics of performance (Stank *et al.*, 2015). Adaptive, resilient and smart supply chains will be a catalyst for greenfield and ongoing development in Northern Australia and support businesses’ sustainability in the long run.

Based on extensive consultations across Northern Australia, this research concludes that ‘business as usual’ is not sustainable. Re-thinking key aspects of supply chains in Northern Australia is needed to ensure that Northern Australia is not left behind in an increasingly globally integrated and competitive market. The post-COVID-19 environment provides an opportunity to critically review the resilience of supply chains and offers diverse options for transformation. This study has highlighted key areas where re-thinking is required. These include a vision with focused priority areas for agriculture, integrated supply chain plans, investment and subsidies in supply chains, coordination and collaboration mechanisms which are multi-sectoral, development of multi-modal east-west supply chain routes, focusing on Asia, addressing workforce challenges and re-thinking infrastructure planning, assessment and decision making.

Re-thinking supply chains in Northern Australia requires a strong evidence base. While research and data are improving, the resources for research and development are limited. However, there are still major gaps in our knowledge regarding supply chains. The gaps include lack of adequate data across the whole of the agricultural supply chains, strengths

and vulnerabilities; lack of granular data about different spatial locations and regions; lack of data on collaboration efforts and key research gaps in workforce, digital ability, market intelligence and governance. Data and evidence collection is patchy as data is fragmented by different industries and jurisdictional collections (e.g. area level, different definitions of regions). There is a need to be more deliberative in the use of data, particularly integration of data on different topics, areas of research and sources and the uptake of research/data in practice by enterprises, policy bodies and apex bodies.

Aspirational, out of the box and innovative thinking and action are needed to develop resilient and robust supply chains in Northern Australia. All relevant stakeholders need to be engaged in a coordinated and collaborative effort to develop adaptive, smart and resilient supply chains in Northern Australia. Addressing supply chain challenges and barriers is critical to the future economic growth, prosperity and wellbeing of all Australia.

REFERENCES

- ACIL Allen Consulting (2020). Regional agribusiness supply chains, Mackay Isaac Whitsunday: Report to Greater Whitsunday Alliance And The CRC For Developing Northern Australia. CRCNA, Townsville. Online version accessed May 2020, <https://crcna.com.au/resources/publications/mackay-isaac-whitsunday-regional-agribusiness-supply-chains>.
- Australian Industry Standards (2019). Transport and logistics skills forecast, Australian Industry Standards and Transport and Logistics Industry Reference Committee, South Melbourne. Online version accessed June 2020, <https://www.australianindustrystandards.org.au/skills-forecast/transport-and-logistics/>.
- Akbar, D., Rahman, A., Rolfe, J., Schrobback, P., Kinnear, S. and Bhattarai, S. (2019). Stakeholder collaboration models for exporting perishable agricultural commodities in Asia: Case for avocado, lychee and mango. Milestones 11-13 Report for CRCNA. CRCNA and Central Queensland University, Townsville. Online version accessed April 2020, https://crcna.com.au/sites/default/files/2019-11/Akbar%20et%20al%20_CRCNA%20project%20milestones%20report%20%28FINAL%20NOV%202019%29%20web.pdf.
- Australian Logistics Council (2016). Getting the supply chain right: Building the economy through efficient and safe supply chains, Australian Logistics Council, Deakin West. Online version accessed April 2020, <https://www.austlogistics.com.au/wp-content/uploads/2016/05/Getting-the-Supply-Chain-Right.pdf>.
- Ash, A. and Watson, I. (2018). Developing the North: Learning from the past to guide future plans and policies. *The Rangeland Journal*, 40, pp. 301–314.
- Australia-ASEAN Chamber of Commerce (AustCham ASEAN) (2019). Capturing the ASEAN agricultural opportunity for Northern Australia, AustCham ASEAN and Cooperative Research Centre for Developing Northern Australia (CRCNA), Townsville. Online version accessed July 2020, <https://crcna.com.au/resources/publications/capturing-asean-agricultural-opportunity-northern-australia>.
- Australian Trade and Investment Commission (2015). Northern Australia: Emerging economies in an advanced economy. Australian Government, Canberra. Online version accessed June

- 2020,
<https://www.austrade.gov.au/International/Invest/Opportunities/northern-australia>.
- Australian Government (2015). Our North, Our Future, White Paper on Developing Northern Australia. Australian Government, Canberra. Online version accessed June 2020,
https://www.industry.gov.au/sites/default/files/June%202018/document/pdf/nawp-fullreport.pdf?acsf_files_redirect.
- Babacan, H. and Tremblay, P. (2020). Reframing supply chains in Northern Australia: Discussion paper. CRCNA, James Cook University and Charles Darwin University, Townsville.
- Babacan, H. and Dale, A. (2019). Emerging rural and regional policy Considerations for Queensland: An overview paper, Rural Economies Centre of Excellence and James Cook University, Cairns.
- Babacan, H., Dale, A. and McHugh, J. (2019). Queensland rural/regional workforce policy analysis. Rural Economies Centre of Excellence & James Cook University, Cairns. Online version accessed June 2020,
<https://www.ruraleconomies.org.au/media/1202/32-recoe-workforce-policy-discussion-paper-june-milestone-32-final.pdf>.
- Bartik, T. J. (2005). Solving the problems of economic development incentives. *Growth and Change*, 36(2), pp.139-166.
- Baum, D. N. (1987). The economic effects of state and local business incentives. *Land Economics*, 63(4), pp. 348-360.
- Beer, A. (2015). Structural adjustment programmes and regional development in Australia. *Local Economy*, 30 (1), pp.21–40.
- Bowden, T. and Thorpe, J. (2020). Australia rebooted. PricewaterhouseCoopers, Sydney. Online version accessed April 2020, <https://www.pwc.com.au/important-problems/australia-rebooted.pdf>.
- Cordon, C. and Buatois, E (Last updated 2020). A post COVID-19 outlook: The future of the supply chain. IMD Research and Knowledge. Webpage accessed on 22 July 2020,
<https://www.imd.org/research-knowledge/articles/A-post-COVID-19-outlook-The-future-of-the-supply-chain/>.
- Commonwealth of Australia (2014). Industry innovation and competitiveness agenda. Australian Government, Canberra. Online version accessed June 2020,
https://www.pmc.gov.au/sites/default/files/publications/industry_innovation_competitiveness_agenda.pdf.

- Commonwealth of Australia (2015). Agricultural competitiveness White Paper. Australian Government, Canberra. Online version accessed July 2020,
https://www.agriculture.gov.au/sites/default/files/documents/ag-competitiveness-white-paper_0.pdf.
- Commonwealth of Australia (2016). Inquiry into national freight and supply chain priorities. Northern Regional Development Australia Alliance (NRDAA), Rockhampton. Online version accessed July 2020,
https://www.infrastructure.gov.au/transport/freight/freight-supply-chain-priorities/files/Inquiry_Report.pdf.
- Commonwealth of Australia (2018). Regions at the ready: Investing in Australia's future. The House of Representatives Select Committee on Regional Development and Decentralisation Commonwealth of Australia, Canberra. Online version accessed July 2020,
https://www.aph.gov.au/Parliamentary_Business/Committees/House/Former_Committees/RegionalDevelopment_and_Decentralisation/RDD/Final_Report.
- Dale, A., Keith, C., Matz, J. and MacLean, B. (2020). Securing outcomes and measuring progress: A preliminary report into agricultural development and tropical health servicing in Northern Australia. Cooperative Research Centre for Northern Australia (CRCNA), Townsville. Online version accessed July 2020,
<https://crcna.com.au/resources/publications/securing-outcomes-and-measuring-progress-preliminary-report-agricultural-development-and-tropical-health-servicing-northern-australia>.
- Department of Agriculture, Water and Environment (2020). Agricultural trade implications of COVID-19. Vol. 11, Department of Agriculture, Water and the Environment, Canberra. Online version accessed July 2020,
<https://www.agribusiness.asn.au/documents/item/569>.
- Deloitte (2020). COVID-19: Managing supply chain risk and disruption. Deloitte, Canada. Online version accessed July 2020,
<https://www2.deloitte.com/global/en/pages/risk/articles/covid-19-managing-supply-chain-risk-and-disruption.html>.
- Deloitte Access Economics (2018). The future of work: Occupational and education trends in supply chain and logistics in Australia. Melbourne. Online version accessed July 2020,
<https://www2.deloitte.com/content/dam/Deloitte/au/Documents/E>

- economics/deloitte-au-economics-future-of-work-occupational-education-trends-supply-chain-logistics-110118.pdf.
- Department of Employment (2016). Demand for labour in Northern Australia: Survey of employers' recruitment experiences: July 2014- April 2015. Australian Government, Canberra. Online version accessed June 2020,
https://docs.employment.gov.au/system/files/doc/other/demand_for_labour_in_northern_australia.pdf.
- Greenville, J., McGilvray, H., Cao., L. Y. and Fell, J. (2020). Impacts of COVID-19 on Australian agriculture, forestry and fisheries trade. Research Report 20/11, Australian Bureau of Agricultural and Resource Economics and Sciences, Australian Government, Canberra. Online version accessed June 2020,
https://daff.ent.sirsidynix.net.au/client/en_AU/search/asset/1030221/0.
- Hall, M. and Frew, J. (2017). Supply chain coordination in Queensland's agricultural sector. Australasian Transport Research Forum, Melbourne. Online version accessed July 2020,
https://www.australasiantransportresearchforum.org.au/sites/default/files/ATRF2016_Full_papers_resubmission_84.pdf
- Higgins, A., McFallan, S., Laredo, L., Prestwidge, D. and Stone, P. (2015). TRANSIT- A Model for simulating infrastructure and policy interventions in agriculture logistics: Application to the Northern Australian beef industry. *Computers and Electronics in Agriculture*, 114, pp. 32–42.
- Infrastructure Australia (2015). Northern Australia Audit, Infrastructure for a Developing North. Australian Government, Canberra. Online version accessed June 2020,
https://www.infrastructureaustralia.gov.au/sites/default/files/2019-06/ia_northern_australia_audit.pdf.
- Infrastructure Australia (2020). An assessment of Australia's future infrastructure needs: The Australian infrastructure Audit 2019. Australian Government, Canberra. Online version accessed June 2020,
https://www.infrastructureaustralia.gov.au/sites/default/files/2020-10/Audit%202019_Full%20pdf_Updates%20September%202020.pdf.
- Jobs Queensland (2018). Anticipating future skills: Jobs growth and alternative futures for Queensland to 2022. Queensland Government. Online version accessed July 2020,

- <https://jobsqueensland.qld.gov.au/wp-content/.../anticipating-future-skills-report.pdf>.
- KPMG, Premise and AEC (2019). North Queensland agricultural market and supply chain study, Townsville Enterprises, and CRCNA, Townsville. Online version accessed June 2020, <https://crcna.com.au/resources/publications/north-queensland-market-and-agricultural-supply-chain-study>
- KPMG and Advance Cairns (2020). Export 2030: Delivering fresh food Fast- The opportunity to double high value, food exports from Far North Queensland. Advance Cairns and CRCNA, Townsville. Online version accessed July 2020, <https://crcna.com.au/resources/publications/export-2030-delivering-fresh-food-fast-opportunity-double-high-value-food-exports-far-north-queensland>.
- Li, Z., Zheng, W., Meng, Q. and Jin, S. (2018). The impact of government subsidy and tax policy on the competitive decision making of remanufacturing supply chains. *International Journal of Sustainable Engineering*, 12(1), pp. 18-29.
- Michelman, P. (2007). Building a resilient supply chain. Harvard Business Review. Online version accessed July 2020, <https://hbr.org/2007/08/building-a-resilient-supply-ch%20May%2011>.
- Mitra, S. and Webster, S. (2008). Competition in remanufacturing and the effects of government subsidies. *International Journal of Production Economics*, 111, pp. (2): 287–298.
- Organisation for Economic Co-operation and Development (2020). COVID-19 and the food and agriculture sector: Issues and policy responses. Paris. Online version accessed July 2020, https://read.oecd-ilibrary.org/view/?ref=130_130816-9uut45lj4q&title=Covid-19-and-the-food-and-agriculture-sector-Issues-and-policy-responses.
- Productivity Commission (2006). Tasmanian freight subsidy arrangements. Productivity Commission Inquiry Report No 39, Productivity Commission, Commonwealth of Australia, East Melbourne. Online version accessed July 2020, <https://webarchive.nla.gov.au/awa/20060917041024/http://www.pc.gov.au/inquiry/tasfreight/draftreport/index.html>.
- Productivity Commission (2014). Public infrastructure. Productivity Commission Inquiry Report. Volume 1, No 71. Productivity Commission, Commonwealth of Australia, East Melbourne. Online version accessed July 2020,

- <https://www.pc.gov.au/inquiries/completed/infrastructure/report/infrastructure-volume1.pdf>.
- Productivity Commission (2017). *Transitioning regional economies. Study Report*, Canberra. Online version accessed July 2020, <https://www.pc.gov.au/inquiries/completed/transitioning-regions/report/transitioning-regionsreport.pdf>.
- PricewaterhouseCoopers (2020). *Northern Australia agriculture investor identification*. Price Waterhouse Coopers and CRCNA, Townsville. Online version accessed June 2020, <https://crcna.com.au/resources/publications/northern-australia-agriculture-investor-identification-and-analysis-report>.
- Riley, G. (Last updated 2020). *Producer subsidies: Government intervention*, A webpage of Tutor2U. Webpage accessed on 20 July 2020, <https://www.tutor2u.net/economics/reference/government-intervention-producer-subsidies#:~:text=A%20subsidy%20is%20a%20form,of%20a%20good%20or%20service>.
- Simpson, G. and Clifton, J. (2016). Subsidies for residential solar photovoltaic energy systems in Western Australia: Distributional, procedural and outcome justice. *Renewable and Sustainable Energy Reviews*, 65, pp. 262–273.
- Stank, T., Autry, C., Daugherty, P. and Closs, D. (2015). Reimagining the 10 megatrends that will revolutionize supply chain logistics. *Transportation Journal*, 54(1), pp. 7-32.
- Transport and Infrastructure Council (2019). *National freight and supply chain strategy*. Commonwealth of Australia, Canberra. Online version accessed July 2020, <https://www.freightaustralia.gov.au/sites/default/files/documents/national-action-plan-august-2019.pdf>.
- Tremblay, P. Babacan, H. and McHugh, J. (2020). *Northern Australia agribusiness supply chains: A review of the literature*. James Cook University, Charles Darwin University and Cooperative Research Centre for Northern Australia, Townsville. Online version accessed July 2020, <https://www.crcna.com.au/resources/publications/northern-australia-agribusiness-supply-chains-review-literature>.
- Wibrow, B. and Circelli, M. (2016). *When one door closes: VET's role in helping displaced workers find jobs*. National Centre for Vocational Education Research (NCVER), Adelaide.