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Bridging the gaps for cross-functional integration in Tzaneen's avocado supply chain

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Background: Tzaneen's avocado supply chain (ASC) plays a critical role in South Africa's avocado industry but faces significant inefficiencies caused by organisational silos, weak communication, postharvest losses, and fragmented coordination across its six supply chain stages. These challenges hinder competitiveness, reduce product quality, and limit the region's ability to respond effectively to global market demands, highlighting the need for improved cross-functional integration (CFI).

Objectives: This study aimed to develop a comprehensive framework for introducing CFI in Tzaneen's ASC by identifying challenges, proposing strategies, determining key stages for enhancement, and creating a cohesive model to reduce silos and improve efficiency.

Method: This is a conceptual article that relies solely on an extensive literature review to build a theoretical framework for understanding and reducing silos in Tzaneen's ASC.

Results: The study reveals that organisational silos, communication gaps, and poor cross-functional coordination across Tzaneen's ASC significantly hinder efficiency, increase postharvest losses, and weaken supply chain performance.

Conclusion: The study concludes that implementing structured CFI is crucial for reducing silos, enhancing information flow, and improving the competitiveness and sustainability of Tzaneen's ASC.

Contribution: This article presents a theoretically grounded framework that identifies the causes of silos and outlines strategies for implementing CFI to enhance collaboration and performance within Tzaneen's ASC.

Keywords: avocado; silos; cross-functional; communication barriers; supply chain.

Introduction

The study analyses the global context of the avocado supply chain (ASC) at the regional level of South Africa's Limpopo ASC. The challenges, supply chain structures, and trends were investigated and analysed to understand the ASC. After examining the global context, the study was narrowed down to the national context of South Africa's ASC. The study then refined the focus further to the regional level of Tzaneen in Limpopo, which is the main subject of the study. The study identified and mapped out the six stages of Tzaneen's ASC: production, distribution, processing, storage, retail, and consumer, to identify where silos are most prevalent in Tzaneen's ASC.

Global supply chains are networks spanning numerous continents and countries that procure and supply goods and services to and from one another (Groom 2022). Within this interconnected system, the avocado industry is characterised by a high degree of production concentration. In 2022, the top seven avocado-producing countries were Mexico, with a production value (in 1000 tons) of 2529; Colombia, 1090; Peru, 866; the Dominican Republic, 737; Kenya, 458; Indonesia, 389; and Brazil, with a production value of 338 (Khosa 2023). Mexico leads globally, producing more than 2.5 million metric tons annually, approximately 30% of world output, with the United States as its primary export market (Bernds 2024; Khosa 2023). Peru and Colombia have rapidly expanded their export infrastructure, capturing significant shares of the European and North American markets (Zang 2023).

South Africa ranks as the eighth-largest avocado producer, accounting for roughly 3% of global production (Khosa 2023). This position is strategically important: it places the country in a competitive arena where volume alone cannot secure market advantage. Instead, success depends

on supply chain efficiency, consistent quality, and the ability to deliver reliably to distant markets. For a producer of this scale, any internal fragmentation, such as the organisational silos documented in the Tzaneen region, directly undermines competitiveness, particularly when rival producers benefit from economies of scale, shorter transit distances to key markets, and increasingly integrated supply chains.

Having established the global competitive landscape, this study narrows its focus to the national context of South Africa's avocado industry before concentrating on the regional supply chain in Tzaneen, Limpopo. The six stages of Tzaneen's ASC, namely production, distribution, processing, storage, retail and consumer, have been identified and mapped to pinpoint where silos are most prevalent (Westfalia Fruit 2021).

As Blanchard (2021) observes, the occurrence of silos within supply chains represents a prevalent challenge that can threaten operational efficiency, particularly in perishable agricultural sectors.

The stages, from avocado production to the consumer, showcase how Tzaneen's strategic geographical positioning and expertise in avocado production play a pivotal role in avocado availability throughout the year (Department of Agriculture, Land Reform and Rural Development [DALRRD] 2020). Efficient harvesting practices and advanced storage techniques ensure year-round availability (Puspitasari et al. 2023). Proper timing and harvesting methods ensure that avocados are picked at optimal ripeness, extending their shelf life (Barboza et al. 2023).

In addition, sophisticated storage solutions, such as controlled atmosphere storage and refrigeration, allow avocados to be stored for extended periods without compromising quality (Kassim & Workneh 2020). These practices help to bridge the gap between harvest seasons, ensuring that avocados can be supplied consistently throughout the year. Furthermore, effective distribution networks and supply chain management ensure that avocados reach various markets promptly, contributing to their year-round availability (Sari 2023).

The six stages of the Tzaneen ASC are intricately connected to Limpopo in South Africa's operations (Westfalia Fruit 2021); however, as Blanchard (2021) notes that the occurrence of silos within the supply chain represents a prevalent challenge that could threaten the efficiency of such operations in agriculture and beyond.

Bento, Tagliabue and Lorenzo (2020) state that the term organisational silos is a metaphor used to illustrate pockets of interaction and knowledge in organisations. Silos within organisations mean communication barriers and the exchange of information (Bento et al. 2020). Silos possess adverse effects insofar as they separate departments (De Waal et al. 2019); silos create a silo mentality where the departments stop sharing information.

This leads to hindering internal collaboration and organisational learning, thus preventing the achievement of high performance and organisational sustainability. Lugo Santiago (2018:20) argues that 'silos negate productivity, multiply duplication of effort and deny access to the talents of the workforce', posing a problem for both small and large businesses alike. Silos will reduce efficiency in the overall operation, reduce morale, and may contribute to the demise of productive company culture; division and distance across teams and specialities form communication barriers, creating insulated pockets of knowledge along geographic and speciality borders. Such fragmentation can hamper a company's ability to utilise existing knowledge fully, potentially hurting its productivity in the long run (Hwang & Krackhardt 2019). McPherson (2024) states that organisational silos prevent teams and departments from sharing resources and information. This fragmentation affects the entire supply chain from production to consumer, causing delays, higher costs, reduced quality, and poor market adaptation (Jenkins 2023).

To foster cross-functional integration (CFI) within the ASC, it is critical to recognise the factors that can lead to such fragmentation. Cross-functional integration is explained by Jackson (2021) as collaboration among various stages and departments to achieve shared vision and goals. Cross-functional integration should occur in the six stages of the ASC.

Pellathy et al. (2019) define CFI in a supply-chain context as:

> [*A*]n ongoing process of collaboration, coordination, and communication, in which the different internal functions that manage a company's supply chain work together to maximise outcomes for their firm and external exchange partners. (p. 84)

While the literature extensively documents both the prevalence of silos in supply chains and the benefits of CFI, there remains a paucity of contextualised, stage-specific frameworks that translate these concepts into actionable strategies for perishable commodity chains in emerging economy contexts. This article addresses this gap. Its primary contribution is the development of a conceptual CFI framework, synthesised from extant literature and tailored to the unique six-stage structure and challenges of the Tzaneen ASC.

This framework serves as a diagnostic and prescriptive tool for both researchers and practitioners.

Conceptual foundations: Defining cross-functional integration and organisational silos

To ensure conceptual clarity, it is necessary to define the two central constructs that underpin this study: organisational silos and CFI. These terms are often used broadly in supply

chain discourse, yet their precise meanings and theoretical underpinnings are critical for understanding the framework proposed herein.

Organisational silos refer to the structural and cultural divisions within or between organisations that inhibit the flow of information, resources, and collaboration across functional boundaries. Bento et al. (2020:2) describe the silo metaphor as 'pockets of interaction and knowledge' that become isolated, leading to communication barriers and fragmented decision-making. This phenomenon is not merely physical but also cognitive; it manifests as a 'silo mentality' where departments prioritise internal goals over collective outcomes (De Waal et al. 2019; Kenton 2020). In supply chain contexts, silos create information asymmetries, duplicate efforts, and undermine the seamless coordination essential for perishable products such as avocados (Jenkins 2023).

Cross-functional integration is advanced as the primary mechanism for dismantling these silos. Cross-functional integration is conceptualised as an ongoing process of collaboration, coordination, and communication among distinct functions or stages to achieve shared objectives (Jackson 2021). In a supply chain context, Pellathy et al. (2019) define CFI as:

> [*A*]n ongoing process of collaboration, coordination, and communication in which the different internal functions that manage a company's supply chain work together to maximise outcomes for their firm and external exchange partners. (p. 84)

This definition emphasises three interrelated dimensions: collaboration (joint problem-solving and shared decision-making), coordination (alignment of activities and resources), and communication (effective information exchange).

The theoretical grounding for CFI draws from systems theory, which posits that organisations and supply chains are complex adaptive systems where interdependence between components determines overall performance (Main 2023; Nica & Chirita 2021). From this perspective, silos represent a failure to recognise and manage interdependence, while integration aligns the system towards emergent, system-level outcomes.

Furthermore, information-sharing theory highlights that transparency across functional boundaries reduces uncertainty and enables proactive responses to disruptions (Tang et al. 2022).

Systems theory, as applied in this study, assumes that the ASC is composed of interdependent stages whose collective performance cannot be understood in isolation. A key assumption is that feedback loops, both positive and negative, govern system behaviour; in the Tzaneen context, the absence of feedback from retail and consumer stages to production represents a broken feedback loop that perpetuates inefficiencies. This theoretical lens justifies the framework's emphasis on closed-loop information flows and collaborative interfaces between stages.

Information-sharing theory, by contrast, assumes that uncertainty is a primary source of supply chain inefficiency and that timely, accurate information exchange among functions reduces uncertainty and enables coordinated action (Li et al. 2019). The theory further assumes that actors will share information when mechanisms for trust and mutual benefit exist (Li et al. 2019). In Tzaneen, the current fragmentation reflects a failure of such mechanisms; therefore, the proposed framework incorporates structured communication platforms and joint planning committees as concrete applications of information-sharing principles. Together, these theories provide a coherent foundation for diagnosing silos and prescribing integration strategies tailored to the perishable, export-oriented nature of the regional ASC.

This study operationalises these constructs within the specific architecture of Tzaneen's ASC.

Organisational silos are identified at each of the six stages, namely production, distribution, processing, storage, retail and consumer, as points where information and coordination break down. Cross-functional integration is then proposed as a set of stage-specific mechanisms, including joint planning committees, shared digital platforms and closed-loop feedback, which directly target these silos. By establishing these definitions and theoretical linkages early, the manuscript provides a clear conceptual lens through which the subsequent analysis and framework can be understood. The Imperative for Integration: Navigating Silos and Systemic Fragmentation in Tzaneen's ASC.

Global avocado trade embodies the complexities and vulnerabilities of modern agricultural supply chains, where geographic distance, perishability, and consumer demand intersect under immense pressure. For regional producers such as those in Tzaneen, South Africa, participation in the lucrative yet volatile market is not merely a function of agricultural yield but of logistical mastery and systemic coordination. The primary constraint on the performance and competitiveness of Tzaneen's ASC is a profound structural and cultural fragmentation, embodied in organisational silos, which severs critical linkages between production, logistics, processing, and market (De Waal et al. 2019). Synthesising literature on global supply chain dynamics, South Africa's competitive position, the specific pathologies of the Tzaneen operation, and the established principles of CFI constructs a compelling case: achieving sustainability and growth is contingent upon deliberately dismantling these silos and fostering a supply chain that operates as a cohesive, information-rich, and adaptive system.

The global arena: A context of concentrated power and acute

Understanding local challenges in Tzaneen requires appreciating the formidable global ecosystem in which the operation functions. The ASC is a quintessential global network, with production heavily concentrated in a handful of countries that leverage climate, scale, and strategic trade partnerships. Mexico stands as the undisputed leader, producing over 30% of global output and dominating exports, particularly to the United States (Bernds 2024:para. 2; Khosa 2023:1). Such concentration creates a market where pricing, quality standards, and seasonal windows are powerfully influenced by the volumes and strategies of leading nations. Following Mexico, countries including Peru, Colombia, and the Dominican Republic have aggressively expanded production and export infrastructure, competing directly in the same northern hemisphere off-season windows crucial for South African exports (Khosa 2023; Zang 2023).

A staggering growth in demand underpins the competitive landscape. Driven by celebrated health benefits, global consumption has surged, with markets in Europe, North America, and increasingly Asia Pacific demonstrating a robust appetite (Mordor Intelligence 2023). Demand is characterised by stringent and non-negotiable expectations: consistent quality, reliable supply, adherence to food safety and ethical certifications, and a lengthening shelf life to withstand long maritime voyages. Groom (2022) elucidates that global supply chains are defined by interconnectedness and exposure to cascading risks from logistical bottlenecks to geopolitical tensions and climate events. For a producer such as South Africa, whose industry contributes a relatively modest 3% of global production, the imperative is clear: to capture value in the concentrated market, competition must occur not on volume alone but on superlative efficiency, impeccable quality, and flawless execution from farm to foreign port.

Any internal inefficiency is magnified in the high-stakes context, directly eroding competitiveness against rivals such as Peru, which leverage geographic proximity to key markets and increasingly sophisticated supply chains (Louw 2020).

South Africa's precarious position: Structural strengths undermined by systemic weaknesses

South Africa's avocado industry is a study in contrast, possessing inherent strengths persistently undermined by systemic weaknesses. A primary asset is agro-climatic: regions including Limpopo, Mpumalanga, and KwaZulu-Natal offer ideal subtropical conditions for cultivating high-value varieties, predominantly Hass, which commands premium prices (Sikuka 2019; South African Avocado Growers' Association [SAAGA] 2020). The industry is a significant economic actor, supporting thousands of permanent and seasonal jobs, particularly in rural economies, and generating vital foreign exchange through exports (Freshplaza 2021). The operational model involves a mix of large-scale commercial producers, focused on exports, and smaller holders serving domestic markets, with packhouses acting as critical intermediaries for grading, packing, and cold storage (Ningi, Lubinga & Dempers 2024).

A series of entrenched challenges jeopardises the promising foundation, collectively pointing to a failure of integration. Logistically, the industry is handicapped by geography. The heartland of production in Limpopo is approximately 1800 km from the primary export hub of Cape Town, a distance that imposes significant costs, transit times, and quality risks (DALRRD 2020). Historical attempts to mitigate the distance through dedicated rail services have faltered because of reliability issues, forcing an over-reliance on road freight, which is vulnerable to fuel price volatility, road conditions, and a shortage of specialised refrigerated containers (Blaauw et al. 2024). Logistical fragility is more than a cost issue; extended transit times and temperature fluctuations degrade fruit condition before reaching the international customer.

Competitively, the sector is losing ground. As Zwane and Ferrer (2024) document, South Africa's rank as an avocado exporter has slipped, outpaced by the rapid expansion of producers in South and Central America.

Decline is attributed to competitiveness issues in the export value chain (DALRRD 2020), a phrase encapsulating a multitude of integration failures. When South African avocados converge with Peruvian fruit in European markets, competition occurs not merely between two fruits but between two supply chains. The more integrated, efficient, and responsive chain secures better shelf space, pricing, and buyer loyalty. South Africa's challenges with logistics, inconsistent quality linked to post-harvest handling, and an inability to swiftly adapt to market feedback reflect a chain operating as a collection of disjointed parts rather than a unified system.

Fragmentation is the core vulnerability that global competitors exploit.

The epicentre of fragmentation: Silos in the Tzaneen supply

Zooming into Tzaneen, a microcosm of the national industry, the abstract concept of fragmentation becomes a tangible, costly reality. The local ASC maps across six sequential but often poorly connected stages: production, distribution, processing, storage, retail export, and consumption (Westfalia Fruit 2021).

At each stage, operations are pursued with dedicated expertise, yet handoffs between stages are fraught with misalignment and information loss. Organisational silos define the domain.

An organisational silo is a metaphor, as Bento et al. (2020) describe, for pockets of isolation where interaction and knowledge are confined within a department or team. A silo mentality represents a mindset where the primary focus becomes the internal goals of the unit, often at the expense of broader organisational or supply chain objectives (De Waal et al. 2019; Kenton 2020). Silos are not merely physical separations but are cultural and procedural, creating formidable barriers to the communication and exchange of information constituting the lifeblood of a smooth operation (Bento et al. 2020). Consequences, detailed across multiple studies of Tzaneen and similar agricultural contexts, are devastatingly concrete.

Firstly, silos are a direct and major contributor to catastrophic post-harvest losses. Research by Dolaso and Shano (2023) in comparable settings indicates losses at the farm level can reach 24%, primarily because of poor handling during manual picking, inappropriate packaging, and substandard storage practices.

Failures of process and coordination, not acts of God, cause such losses. For instance, harvest teams operating in a silo, focused solely on speed or volume, may use techniques causing bruising, compromising fruit integrity for the entire subsequent journey. Damaged fruit then enters a distribution silo, where transporters, unaware of its delicate state or prioritising truck utilisation over careful handling, subject it to excessive vibration on poor roads (Bezuidenhout et al. 2020; Ríos-Mesa et al. 2020). Damage often remains invisible until the ripening process at the retailer, at which point accountability is lost, and there is total financial loss. The sequence exemplifies how a silo at one stage multiplies costs and failures downstream, a phenomenon Jenkins (2023) identifies as the core of supply chain fragmentation.

Secondly, silos fatally compromise quality and shelf-life management, the very metrics determining export success. The science of avocado post-harvest is precise: harvesting at the exact correct maturity, immediate precooling, maintenance of an unbroken cold chain, and careful handling are non-negotiable (Kassim & Workneh 2020; Munhuweyi, Mpai & Sivakumar 2020). Seamless collaboration is required for such science.

A farmer harvesting without real-time information on packhouse capacity or cold storage availability may be forced to hold fruit in suboptimal conditions. A transporter without access to precise temperature requirements or the packhouse receiving schedule may break the cold chain. As Barboza, Freitas Silva and Fonseca (2023) emphasise, perceptions and practices at the harvesting phase directly cascade through the chain. When each stage operates as a silo, precise science disintegrates into a series of best guess operations, resulting in fruit ripening unevenly, developing internal disorders, or spoiling prematurely, directly translating to financial loss and reputational damage in exacting markets such as the European Union.

Thirdly, silos cripple market responsiveness and strategic alignment. The final stage of the chain, the consumer in Europe or Asia, is geographically and informationally distant from the first stage, the farmer in Tzaneen.

In an integrated chain, feedback on quality issues, ripening trends or consumer preferences would flow swiftly upstream, enabling adjustments in harvesting, variety selection, or packaging. In a siloed chain, the feedback loop is broken.

Retailers may complain to exporters, but information may not reach processors in an actionable form and almost certainly never reaches farmers in time to alter practices for the next harvest (Sari 2023). A lack of a closed loop leaves producers operating in the dark, repeatedly making the same mistakes while markets evolve. Prevention of the chain acting as a learning, adaptive system locks the operation into reactive and often disadvantageous positions.

The integrative antidote: Principles and power of cross functional integration

Confronted with evidence of silo-driven inefficiency, literature converges on a robust solution: deliberate and structured implementation of CFI. Cross-functional integration moves beyond vague appeals for better teamwork to offer a defined operational philosophy. Pellathy et al. (2019) provide a seminal definition, framing integration as an ongoing process of collaboration, coordination, and communication, in which different internal functions managing a company's supply chain work together to maximise outcomes for their firm and external exchange partners. The definition underscores that CFI is not a one-off project, but a continuous discipline centred on collaboration, coordination, and communication.

The theoretical and empirical case for CFI is powerful. At its core, integration addresses the fundamental problem of the silo: information asymmetry. Tang et al. (2022) posit that information sharing is the critical mechanism enabling collaboration. When procurement, farming operations, logistics, and sales share information openly about demand, capacity, challenges, and market conditions, they can work together to solve problems and make better decisions instead of working separately. Creating formal and informal channels for communication, as advocated by Jackson (2021), who distinguishes between structured initiatives like joint planning committees and softer, trust-based interactions fostering mutual understanding, is crucial, not merely technology.

Documented benefits are multifaceted. Internally, CFI breaks down duplicative efforts and resolves conflicts stemming from misaligned priorities (Flynn, Huo & Zhao 2010). Integration enables the development of shared key performance indicators rewarding collective success

rather than parochial victories. For example, instead of rewarding farmers solely on yield, which may encourage harvesting immature fruit, and transporters solely on cost per kilometre, which may encourage overloading, an integrated key performance indicator might focus on the percentage of Grade A fruit delivered on time to the packhouse, aligning interests across the first two stages.

Externally, CFI builds supply chain resilience. Modern chains face constant disruptions from climate events such as hail (Steyn 2020) to pest outbreaks such as the Polyphagous Shot Hole Borer (De Wit et al. 2022) or global logistical crises. Research by Poberschnigg et al. (2020) and Van den Adel et al. (2023) demonstrates that cross-functional teams are essential for organisational resilience. When a disruption hits, a siloed organisation responds slowly and in pieces. An integrated operation can convene a team spanning farming, logistics, and sales to rapidly scout for information, assess impacts, and develop a coordinated response, such as rerouting shipments or communicating proactively with buyers. Adaptive capacity is a decisive competitive advantage in a volatile world.

Furthermore, CFI is the essential enabler for implementing advanced quality and sustainability protocols. Meeting Global G.A.P., organic, or carbon footprint standards requires traceability and consistent practice across the entire chain, which is impossible if stages are not communicating and coordinating (Kota & Bandi 2014). As Pålsson and Sandberg (2022) observe in work on sustainable packaging, silos between logistics, production, and marketing often lead to inefficient and unsustainable outcomes because no single department has the complete picture or incentive to optimise for the whole.

Synthesis: From diagnosis to prescription in Tzaneen

The trajectory of the argument is clear. Tzaneen's ASC operates within a brutally competitive global market where rivals leverage scale and integration. A national context presents specific logistical and competitive hurdles. However, the most debilitating constraint is endogenous: a self-imposed fragmentation through organisational silos manifesting in quantifiable losses, quality defects, and strategic myopia. Silos create a chain that is less than the sum of its parts, where excellence at one stage is nullified by failure at the next.

Scholarly and practical consensus points unequivocally to CFI as the necessary corrective. Integration provides the framework, through collaboration, coordination, and communication, to rebuild broken linkages, align disparate incentives, and facilitate the flow of information as critical as the flow of fruit. Transformation of a linear, sequential chain into a dynamic, interactive network capable of learning, adapting, and competing becomes possible.

Therefore, the critical task is not merely to acknowledge the need for CFI in the abstract, but to contextualise and operationalise integration for the specific six-stage architecture of Tzaneen's ASC. The following section will undertake synthesis, drawing directly on challenges catalogued and CFI principles defined, to construct a targeted conceptual framework.

The framework will propose specific integrative mechanisms for each stage-to-stage interface, offering a practical blueprint to dismantle silos, capture lost value, and reposition Tzaneen's industry for sustainable competitiveness in the global arena.

Literature review methodology

To ensure the rigour and transparency of the conceptual framework development, a systematic approach to the literature review was adopted. The review aimed to identify and synthesise existing knowledge on organisational silos, CFI, and supply chain challenges within the avocado industry, with a specific focus on the Tzaneen region.

A structured search was conducted across the following academic databases: Scopus, Web of Science, Google Scholar, and Sabinet (for South African-focused literature). The search employed combinations of keywords including 'avocado supply chain', 'organisational silos', 'cross-functional integration', 'postharvest losses', 'Tzaneen', 'Limpopo', and 'South African agriculture'. In addition to peer-reviewed journal articles, the search incorporated grey literature such as industry reports from the SAAGA, the 'Strong Domestic and Export Demand Drives Growth in South African Avocado Plantings' report (Pretoria, South Africa, 24 February 2021), the 'South African Avocado Tree Census 2025' by Subtrop, the 'Smart Technology: Tracks and Traces How Avocados Move Through Packhouses' article published in the *SA Fruit Journal*, and various industry-specific reports and trade data sheets related to South African avocado production, trade, and market analysis. This multisource approach was essential to capture both academic theory and context-specific operational realities.

Articles and reports were included if they met the following criteria: (1) published in English between 2010 and 2024, ensured contemporary relevance; (2) focused on supply chain management, post-harvest handling, or organisational integration in agricultural, particularly perishable, contexts; (3) provided empirical or conceptual insights applicable to the South African or comparable emerging economy settings; and (4) where applicable, explicitly referenced the Tzaneen region or Limpopo province. Excluded were sources that addressed avocado production without supply chain implications, studies focused solely on non-agricultural industries, and articles lacking methodological clarity.

From an initial pool of 214 identified sources, 87 were selected for full-text analysis after screening titles and abstracts against the inclusion criteria. A data extraction template was used to record for each source: author, year, geographical focus, key constructs, methodological approach, and findings relevant to silos or integration. The synthesis followed a thematic analysis approach, where recurring themes such as communication breakdowns, post-harvest losses, and coordination gaps were identified and grouped according to the six supply chain stages (production, distribution, processing, storage, retail, consumer). Company reports and industry documents were analysed to map the specific challenges reported in Tzaneen. This iterative process allowed the authors to derive the stage-specific challenges and integration mechanisms that form the basis of the conceptual framework. The resulting framework was then refined through cross-referencing with established theoretical literature on CFI to ensure conceptual grounding.

The methodology described ensures that the framework is not merely a product of selective reading but is grounded in a transparent, reproducible process. By clearly specifying the sources, search terms, inclusion criteria, and analytical steps, the study provides readers with the necessary information to assess the credibility of the literature-based development process and to replicate or build upon the synthesis in future research.

A proposed conceptual framework for cross-functional integration in Tzaneen's avocado supply chain

Synthesising the extensive literature review, this section presents the study's central contribution: a stage-specific conceptual framework designed to foster CFI and dismantle organisational silos within Tzaneen's ASC. Table 1 presents the mapped supply chain challenges identified from the reviewed company reports and industry documents, together with the corresponding CFI mechanisms proposed to address these operational and organisational inefficiencies across Tzaneen's ASC.

Table 1 presents a synthesis of the specific supply chain challenges identified from the reviewed company reports, market intelligence publications, and industry documents, together with the corresponding CFI mechanisms proposed to address these challenges. The findings reveal recurring patterns of fragmentation across the ASC, particularly in relation to communication breakdowns, weak cold-chain coordination, inconsistent quality management practices, limited information sharing, export logistics inefficiencies, and poor integration between producers, processors, distributors, retailers, and consumers. The reviewed reports further indicate that these challenges are intensified by fluctuating international market conditions, stringent phytosanitary requirements, and the export-oriented nature of the South African avocado industry. In response, the mapped integration mechanisms emphasise collaborative planning structures, shared information systems, integrated quality assurance procedures, coordinated logistics management, digital communication platforms, and continuous feedback loops across the six stages of the supply chain. The table therefore demonstrates that the proposed conceptual framework is not developed in abstraction but is grounded in the practical operational realities and systemic challenges identified within the Tzaneen ASC and the broader South African avocado industry.

TABLE 1: Mapping of supply chain challenges and cross-functional integration mechanisms identified from reviewed company reports and industry documents.

Reviewed report and industry document	Specific challenges identified in the report	Cross-functional integration mechanisms proposed	Relevance to proposed conceptual framework
A Profile of the South African Avocado Market Value Chain (2017)	Fragmented value chain coordination, inconsistent quality management, weak cold-chain integration, export dependency, logistics inefficiencies, packaging and phytosanitary compliance challenges.	Integrated cold-chain management systems, collaborative quality assurance protocols, shared compliance systems, coordinated export logistics, integrated packaging and traceability systems	Demonstrates how fragmented operational processes across production, storage, logistics, and export stages contribute to silos requiring structured integration mechanisms
Avocado Market Intelligence Report (2020)	Global competition pressures, inefficient export coordination, fluctuating market demand, supply inconsistencies, weak responsiveness to international markets, logistical vulnerabilities, and limited strategic coordination.	Shared market intelligence platforms, collaborative forecasting, integrated export planning, coordinated stakeholder communication systems, and joint strategic planning structures	Supports the framework's emphasis on information sharing and coordinated decision-making across the six supply chain stages
South African avocado industry reports (SAAGA and industry publications cited in the article)	Post-harvest losses, poor handling practices, fragmented communication between growers, distributors, processors, and retailers, inconsistent quality standards, and weak feedback systems.	Closed-loop communication systems, integrated handling protocols, real-time quality monitoring, collaborative training initiatives, and shared operational standards	Provides empirical justification for introducing continuous communication and feedback loops throughout the supply chain
Export logistics and EU compliance documentation discussed in industry reports	Tariff barriers, phytosanitary regulations, packaging compliance requirements, and weak coordination in export preparation processes.	Cross-functional compliance teams, integrated export documentation systems, shared regulatory databases, and coordinated logistics planning	Reinforces the framework's recommendation for coordinated regulatory and export management structures
Distribution and retail analysis within the avocado value chain reports	Weak retailer–producer communication, delayed market feedback, inconsistent demand forecasting, and limited customer responsiveness.	Shared digital communication platforms, collaborative demand forecasting, retailer–producer integration meetings, and customer feedback systems	Informs the framework's retail-to-production feedback integration mechanisms
Organisational and logistics analysis sections of the avocado market reports	Siloed organisational structures, disconnected operational functions, inefficient transport coordination, and weak integration between processing, storage, and distribution	Joint planning committees, integrated transport scheduling systems, interdepartmental coordination structures, and shared performance indicators	Directly informs the conceptual framework's cross-functional integration architecture for the six stages of Tzaneen's avocado supply chain

SAAGA, South African Avocado Growers' Association; EU, European Union.

The framework is built upon a dual synthesis. Firstly, it consolidates the critical silo-related challenges identified across the six stages of the local supply chain. Secondly, it aligns these challenges with relevant CFI mechanisms drawn from broader supply chain theory. The resultant model serves as both a diagnostic tool for pinpointing disconnections and a prescriptive roadmap for implementing targeted integration strategies.

The analysis reveals that silos in Tzaneen manifest as distinct yet interconnected barriers at each supply chain stage. At the production stage, challenges include poor harvesting timing and techniques, inadequate pest management, and a lack of real-time communication with downstream partners regarding quality standards and volume forecasts. The distribution and transportation stage is plagued by inefficiencies stemming from a disconnect between farmers, packhouses, and logistics providers, leading to suboptimal routing, inadequate refrigerated transport, and significant vibration damage during transit. Within processing and storage, silos arise between quality inspectors, packhouse operators, and inventory managers, resulting in inconsistent grading, inefficient cold storage management, and poor traceability. The retail and consumer interface suffers from a critical feedback gap, where valuable information on shelf-life performance, customer preferences, and quality issues fails to circulate back to producers and processors.

To address these discrete yet interrelated problems, the framework proposes the strategic application of CFI mechanisms at the interfaces between each stage.

These mechanisms are conceptualised as bridging tools designed to enhance the three fundamental processes of collaboration, coordination, and communication. For instance, to integrate the production and distribution stages, the framework advocates for the establishment of joint planning committees comprising farm managers and logistics coordinators. These committees would synchronise harvest schedules with vehicle availability, share data on farm-gate quality and road conditions, and develop shared key performance indicators focused on reducing transit-related losses.

The implementation of a shared digital platform is proposed between the distribution and processing stages.

This platform would facilitate the real-time exchange of vital data, including delivery times, pre-cooling status, and initial quality assessments, allowing packhouse operations to dynamically adjust their receiving and processing schedules. Furthermore, the framework emphasises the need for cross-functional quality management teams that include representatives from production, processing, and storage. These teams would work collaboratively to standardise quality protocols, oversee the implementation of advanced post-harvest treatments, and manage controlled atmosphere storage to extend shelf life consistently.

Perhaps most critically, the framework introduces a closed-loop feedback mechanism designed to integrate the retail and consumer stage with upstream production. This involves creating formalised channels for retailers to report on product performance, ripening rates, and customer complaints directly to growers and packhouses. This information would then inform adjustments in harvesting maturity, packaging materials, and storage protocols, thereby directly linking consumer satisfaction to on-farm and packhouse practices.

The visual representation of this framework, presented in Figure 1, maps these proposed integration mechanisms onto the linear flow of the six-stage supply chain. It illustrates that CFI is not a singular activity but a series of deliberate, stage-specific interventions that collectively transform a fragmented chain into a cohesive system. The framework posits that its successful application requires foundational enablers, including committed leadership to champion a shared vision, investments in appropriate and accessible information technology, and the development of trust through formal and informal relationship-building initiatives among stakeholders across the chain. This conceptual framework thus provides a structured, theory-informed approach for practitioners in Tzaneen to diagnose silos and prioritise integration efforts, while offering researchers a testable model for future empirical validation in similar perishable supply chain contexts. The proposed conceptual framework for CFI within Tzaneen's ASC is illustrated in Figure 1.

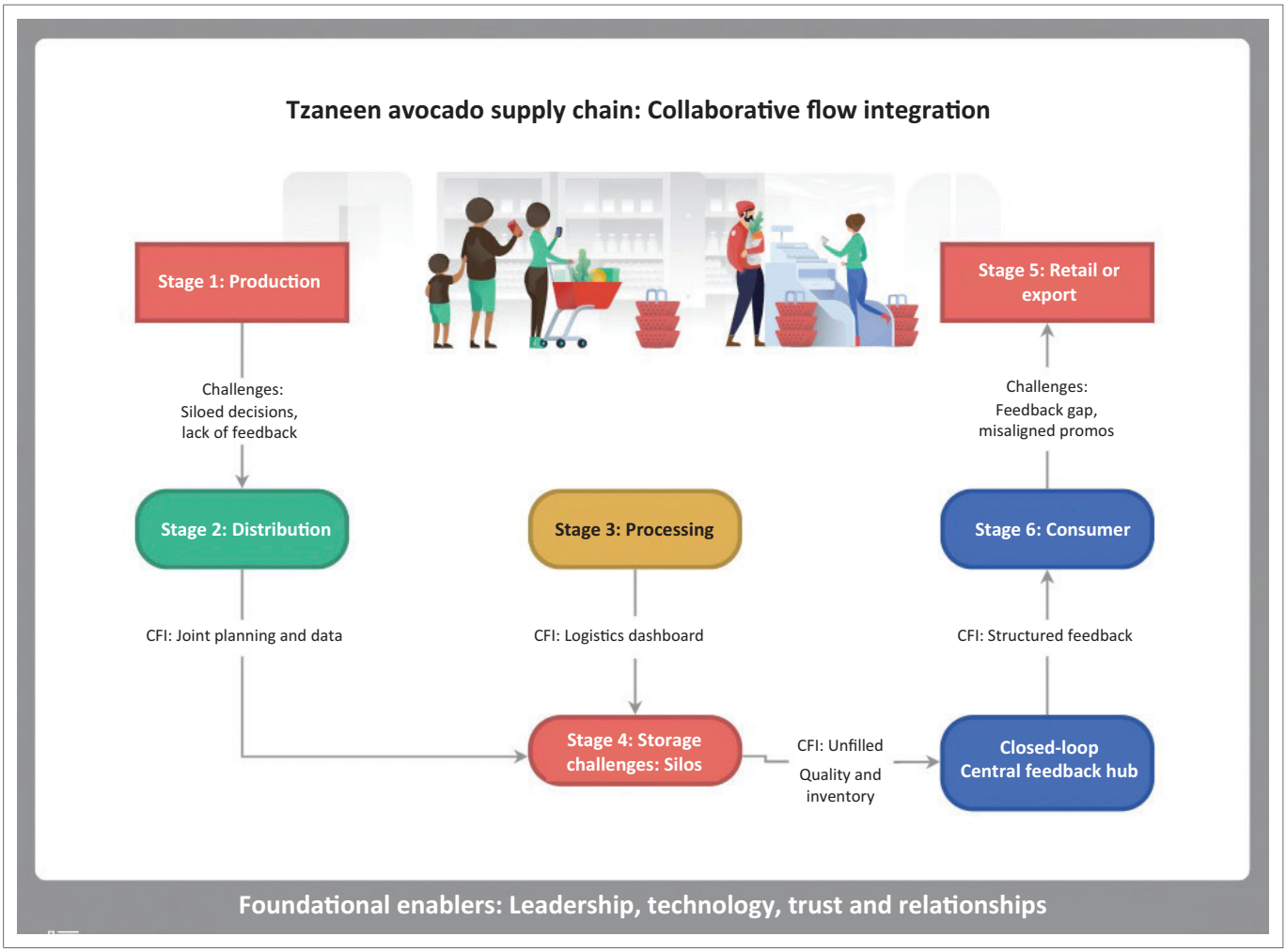
Figure 1 provides a visual synthesis of the stage-specific challenges and integration strategies central to this study. The diagram maps the six linear stages of the supply chain, from production through to the consumer, each pillar housing the key silo-related inefficiencies identified in the literature. Crucially, the model moves beyond merely diagnosing these problems by introducing dedicated integration bridges between each stage.

These bridges contain targeted mechanisms for collaboration, coordination, and communication, such as joint planning committees and shared digital platforms, designed to dismantle the specific barriers at each interface.

A defining feature of the framework is the closed-loop feedback arrow, which arcs from the consumer back to production, embodying the essential flow of market intelligence required for continuous improvement.

Supporting the entire structure are three foundational enablers: leadership and shared vision, appropriate technology, and trust and relationship capital. Collectively, this framework transforms a theoretical understanding of silos into a structured, actionable roadmap for achieving a cohesive, efficient, and responsive ASC in the Tzaneen region.

The operational logic of the framework is best understood by tracing how each proposed mechanism bridges the gaps



CFI, cross-functional integration.

FIGURE 1: A framework for cross-functional integration in Tzaneen's avocado supply chain.

identified in Figure 1. For instance, the joint planning committees shown between the production and distribution stages are operationalised through monthly cross-functional meetings where farm managers and logistics coordinators share harvest forecasts, cold storage availability, and vehicle scheduling data. This mechanism directly addresses the silo challenge of misaligned harvest and transport planning by embedding communication and shared performance targets into routine practice. Similarly, the shared digital platform indicated between distribution and processing is operationalised as a cloud-based system that transmits real-time information on fruit temperature, estimated arrival times, and packhouse capacity.

By enabling dynamic scheduling and pre-cooling coordination, this mechanism mitigates the fragmentation that otherwise leads to cold chain breaches and fruit quality degradation. At the retail-consumer interface, the closed-loop feedback mechanism is operationalised through formalised quarterly reporting from retailers to producers, capturing data on ripening consistency, shelf-life performance, and consumer complaints. This information is then channelled back to farm-level decision-making on harvest maturity and post-harvest handling, thereby transforming the previously broken feedback loop into an actionable driver of continuous improvement. In this manner, the visual schematic in Figure 1 is not merely a static representation but a map of specific, implementable interventions whose operational details are derived directly from the challenges documented in the preceding analysis.

Conclusion

This study has undertaken a comprehensive exploration of the barriers to efficiency within Tzaneen's ASC, systematically identifying organisational silos and communication gaps as the foundational causes of post-harvest losses, reduced quality, and diminished global competitiveness. Through an extensive synthesis of global supply chain literature and local industry analysis, the research has moved beyond merely cataloguing these challenges. Its primary and original contribution lies in the development of a novel, stage-specific conceptual framework for CFI, tailored explicitly to the unique operational, geographical, and economic realities of the Tzaneen context.

The proposed framework translates abstract principles of collaboration, coordination, and communication into actionable strategies at the critical interfaces between production, distribution, processing, storage, retail, and consumption. By advocating for mechanisms such as joint planning committees, shared digital platforms, cross-functional quality teams, and closed-loop feedback systems, the model provides a clear diagnostic and prescriptive tool for supply chain stakeholders. It demonstrates that silo reduction is not a monolithic endeavour, but a series of targeted interventions designed to foster a shared vision and interdependent operations across the entire chain.

Theoretical implications of this work are significant. It advances supply chain integration theory by contextualising it within a perishable, export-oriented agricultural system in an emerging economy. The framework highlights how standard integration principles must be adapted to address acute challenges such as infrastructural limitations, geographic dispersion, and the biological imperative of preserving fruit quality.

For practitioners and policymakers within the South African avocado industry, the study offers immediate, pragmatic value. It directs managerial attention and investment towards the most impactful leverage points for integration, suggesting that prioritising information flow between farmers and logistics providers and establishing robust quality feedback loops from market to farm could yield substantial improvements in profitability and sustainability.

It is important to acknowledge the primary limitation of this research: as a conceptual article, the framework is derived from literature rather than empirical testing. Its efficacy and practical applicability require validation through engaged case study research or action research projects within Tzaneen's ASC. Such validation could be supported by Delphi studies that gather and structure expert consensus from Tzaneen's avocado farmers, warehouse managers, and logistics providers to refine the framework's mechanisms, or by a longitudinal case study of a specific cooperative or warehouse that implements the proposed integration strategies and tracks performance indicators over time. Future research should therefore focus on implementing and monitoring the proposed integration mechanisms, measuring their impact on key performance indicators such as post-harvest loss percentages, on-time delivery rates, and export quality compliance. Furthermore, investigating the role of digital traceability technologies and the impact of sustainability certifications on cross-functional collaboration would be valuable extensions of this work.

In conclusion, the competitiveness and sustainability of Tzaneen's vital avocado industry hinge on its ability to transcend entrenched silos. This study contends that a deliberate, structured approach to CFI, as outlined in the proposed framework, is not merely beneficial but essential. By fostering a cohesive, collaborative supply chain ecosystem, stakeholders can enhance efficiency, improve product quality, and more effectively respond to the stringent demands of the global market, thereby securing the long-term prosperity of this important regional sector.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

CRediT authorship contribution

Anthea P. Amadi-Echendu: Conceptualisation, Data curation, Formal analysis, Writing – review & editing. Matshidiso Tsholetsane: Conceptualisation, Writing – original draft. All authors reviewed the article, contributed to the discussion of results, approved the final version for submission and publication, and take responsibility for the integrity of its findings.

Ethical considerations

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Data availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

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