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Determining Factors Driving Sustainable Performance Through the Application of Lean Management Practices in Horticultural Primary Production

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ABSTRACT: This study investigates the determining factors that drive sustainable performance through the application of management lean methods in the primary production segment of the horticultural supply chain for apples and pears. The determining factors, identified through a systematic review of the available literature, are thematically synthesized, conceptually framed and utilized for the development of a case study. The single case study approach is utilized to develop a detailed and nuanced understanding of the context, evaluating the practices of 4 cooperative primary producers operating within a forward integrated supply chain. The study posits that the combination of climatic and biophysical dynamism inherent in the primary producer environment, in combination with the inflexibility of seasonal batch production, imposes itself as a key barrier to the imposition of pull and flow in the chain, the fundamental tenets of a lean system. A case is outlined where cold infrastructure is employed to break the inflexibility of supply whilst a process of forward contracting establishes fruit orders up to 1-year in advance, beyond the forthcoming annual cycle, functionally transforming fruit cultivation within the group from a "push" to a "pull" system of production. It is further highlighted that functional partitioning of the organizational-chain structure is necessary to isolate and mitigate the effects of contextual dynamism, whereby downstream chain structures purposed for agility and responsiveness serve as a protective buffer to lean focused grower operations. The findings reaffirm the positive relationship between the size of the grower operation, the capacitation of the workforce and the ability of the operation to attain superior lean driven performance outcomes. However, it is severally highlighted that horizontal cooperation between primary producers may help overcome the resource limitations of smaller growers. Data based decision controls are marked as being centrally important sustainable performance determinant, both at the level of the grower, in terms of orchard management and harvest process control, as well as at the level of the cooperative serving the needs of crop programming and practice benchmarking processes. This exposition of determining factors driving lean sustainable performance in horticultural primary production represents a new contribution to the body of literature linking lean and sustainable organizational performance. The study should support further development of lean management research and practiced lean methods within the agri-food context.

1. Introduction

The global agri-food system faces the challenge of having to increase food production in the context of increasingly limited agricultural productive capacity (Davis et al., 2016; Godfray et al., 2012). Current modes of agricultural production carry with them a significant environmental and social burden which cannot be maintained indefinitely (Foley et al., 2011; Power, 2010; Vitousek, Mooney, Lubchenco, & Melillo, 1997) and if the global agri-food system is to have any hope of keeping pace with the growing demand for food, the means of agricultural production, by necessity, will need to become more sustainable (Davis et al., 2016; Godfray et al., 2012; Tey et al., 2014). Across various manufacturing and services sectors, researchers have explored and established the potential for managerial systems to drive sustainable organizational performance (Chiarini, 2015). Lean methods in particular, being intrinsically anthropocentric, pragmatic and tightly focused on waste reduction, have been shown to be highly congruent with organizational sustainability strategies and practices (Fliedner & Majeske, 2010). This has resulted in the emergence of a body of research detailing the relationship between lean methods and sustainable organization and supply chain performance (Martínez-Jurado & Moyano-Fuentes, 2013; Piercy & Rich, 2015). This research trend has continued into the agri-food sector, where several authors have initiated investigations into the potential for lean methods to drive sustainable performance at various levels in the agri-food supply chain (Colgan, Adam, & Topolansky, 2013; Cox & Chicksand, 2005; Cox, Chicksand, & Palmer, 2007; Simons & Zokaei, 2005). However, this area of research remains relatively underdeveloped and the available studies linking lean and agri-food production leave gaps in three key respects. Firstly, of the available studies linking lean and agri-food production, only one study, (Colgan et al., 2013), assumes a primary producer perspective; whilst the remainder only address primary production as a component of an overarching supply chain perspective. Secondly, all of the available studies addressing this topic are focused on the red meat sector; none have addressed fresh fruit production. Lastly, this available body literature assumes a relatively narrow perspective of lean management, addressing only a small subset of lean principles and practices, and a limited number of contextually located determining factors that shape lean performance outcomes. Thus, an in-depth exposition of the determining factors explaining lean driven sustainable performance in primary production represents a prominent gap in the available literature. This study seeks to contribute to these unaddressed areas, through an investigation into the emergence and application of lean methods in the intensive horticultural production of apples and pears.

Consequently, the specific research questions investigated in this study are as such: Firstly, what are the determining factors that drive sustainable performance through the application of lean methods? Secondly, how do these determining factors influence the application of lean methods to drive sustainable performance in horticultural primary production? The proceeding chapters of this study, directed toward addressing these research questions, are organized as follows: Chapter 2 contextualizes this study in the prevailing body of literature. The studies comprising the existing body of lean agriculture literature are summarized and discussed whilst the specific contingency factors influencing the practice of operations management in the agricultural primary production context are identified and highlighted. Moreover, the determining factors that drive sustainable performance through the application of lean management practices, identified through a systematic review of the literature, are detailed, thematically categorized and discussed. In chapter 3 the theoretical framework purposed to provide structure to the analysis of the case is outlined whilst the various methodological elements integrated into the research design are examined and evaluated. The case study is presented in chapter 4 where the key strategic and operational considerations of apple and pear horticulture are discussed at length. Here the lean configuration of the strategic and operational elements is presented as a tightly coupled system of practices, where the constituent elements hold together in mutual dependence (Shah & Ward, 2007) and where the self-reinforcing effects of this dependence contribute to the superior performance attained (Shah & Ward, 2003). Finally, a functional analysis of the case is presented in chapter 5 followed by chapter 6 which closes with the conclusions, limitations of the study and possibilities for future research.

2. Literature

2.1 Lean and Sustainability

The adoption of lean has been evident across a broad range of economic sectors, which in many cases has resulted in improved performance and competitiveness (Martínez-Jurado & Moyano-Fuentes, 2013). However, in the evolving market place it is not sufficient for companies to simply be improving their economic performance as these organization face changes in laws and regulations as well as pressure and demands from the various stakeholders to develop greater environmental and social responsibility (Gordon, 2001). They need to develop greater cognizance of the impact of their operations on the environment and society and need to be seen to be managing their businesses more responsibly (Taubitz, 2010). Lean management's intrinsic focus on waste reduction coupled with its people centered hands on pragmatism provide for an inherent congruency between the lean paradigm and sustainability strategies and tactics. It is pointed out by (Piercy & Rich, 2015) that though the adoption of lean methods and sustainability strategies have emerged and continued almost independently of one another, they have, over time, shown to be very complimentary mechanisms. Organizations face immense pressure having to attend to the multifaceted aspects of sustainability, and thus (Garza-Reyes, 2015) points out that sustainability as a strategy needs to be aligned to the traditional priorities of profitability and efficiency. It is posited by (Bortolotti, Romano, Martínez-Jurado, & Moyano-Fuentes, 2016) that since lean management is an integrated management system, it is relatively unaffected by these challenges of integration and followingly this inherent characteristic acts as a driver behind the growing interest in the links between lean management and sustainability. Additionally (Fliedner & Majeske, 2010) highlight that the central pillar of lean is waste reduction and elimination of non-value adding activities, a tenet that is fundamentally supportive of sustainable operations.

The linkages between lean management and environmental and social sustainability are evident in a considerable and growing body of literature (Dhingra, Kress, & Upreti, 2014; Garza-Reyes, 2015; Martínez-Jurado & Moyano-Fuentes, 2013) whilst (Fliedner & Majeske, 2010) advances that linkages with sustainable performance represent the new frontier for lean research. The environmental performance benefits of lean management have since been well established, demonstrating performance improvements in areas of reduced environmental impact (Pampanelli, Found, & Bernardes, 2014), improved resource efficiency (Bergmiller & Mccright, 2009) and reduced risk stemming from regulatory non-compliance (Vinodh, Arvind, & Somanaathan, 2011). The body of work broaching lean and social sustainability linkages has not received quite as much attention, but is an important emerging and growing theme in the literature (Cherrafi, Elfezazi, Chiarini, Mokhlis, & Benhida, 2016a; Martínez-Jurado & Moyano-Fuentes, 2013). Thus far studies in this area have maintained a relatively narrow employee centric focus, positing benefits to employee morale and commitment (Piercy & Rich, 2015), improved work environment (Jarebrant, Winkel, Hanse, Mathiassen, & Ojmertz, 2016) and improved employee awareness of sustainability challenges (Dakov & Novkov, 2007), among others.

The body of available literature is important not only because it details the environmental and social impacts of lean management practices, but also because it provides exposition regarding the various contingency factors that drive the successes or failures associated with the application of lean methods. As stated by (Dora, Kumar, & Gellynck, 2015) the question of why some firms perform better than others when applying the same practices is an important driver of research in the field of operations management. In relation to the determining factors that drive sustainable organizational performance through the application of lean methods, thematic analysis of the available body of literature reveals 6 broad categories; summarized here in Table 1. In summary:

Table 1: Determining factors identified in the literature

Determining factors:	Sources:
Knowledge	▪ Knowledge of sustainability and lean concepts and practices (Koranda, Chong, Kim, Chou, & Kim, 2012)(Dutt & King, 2014)(Bergenwall, Chen, & White, 2012) ▪ Contextual Knowledge (Rothenberg, 2003) ▪ Specialist Knowledge/Skills (Rothenberg, 2003) ▪ Common areas of value between organization and company (Aguado, Alvarez, & Domingo, 2013)(Bergenwall et al., 2012) ▪ Perceptions of value between organizational stakeholders (Koranda et al., 2012)(Dutt & King, 2014)(Büyüközkan, Kayakutlu, & Karakadılar, 2015)
Workforce and Training	▪ Training (Chaplin, Heap, & O'Rourke, 2016)(Herron & Braiden, 2006)(Vinodh, Ramesh, & Arun, 2016)(Vinodh, Ramesh, et al., 2016) ▪ Teamwork (Pagell, Dibrell, Veltri, & Maxwell, 2014)(Longoni, Golini, & Cagliano, 2014) ▪ Self-direction and worker participation (Rao, 2004)(Rothenberg, 2003) ▪ Procedures and work habits (Jeffers, 2010) ▪ Worker needs and workplace ergonomics (Wong & Wong, 2014)(Jarebrant et al., 2016)
Operational Context	▪ Marketplace complexity (Cabral, Grilo, & Cruz-Machado, 2012)(Herron & Braiden, 2006) ▪ Marketplace dynamism (Büyüközkan et al., 2015)(Sekar, Vinoth, & Sundaram, 2015) ▪ Increasing/Dynamic customer expectations (Sekar et al., 2015) ▪ High number/variety of stakeholders in supply chain (Nagalingam, Kuik, & Amer, 2013)
Organizational Structure	▪ Size and magnitude of practice (Thoumy & Vachon, 2012)(Hajmohammad, Vachon, Klassen, & Gavronski, 2013) ▪ Suppliers (Rao, 2004) ▪ Site-Layout (Wu, Low, & Jin, 2013)(Lapinski, Horman, & Riley, 2006) ▪ Culture (Verrier, Rose, Caillaud, & Remita, 2014)

	▪ Resource availability (Chaplin et al., 2016)(Verrier et al., 2014)
Alignment, Integration and Prioritization	▪ Degree of integration of sustainability objectives (Rosenbaum, Toledo, & González, 2014)(Lapinski et al., 2006) ▪ Prioritization of management or infrastructure (Thoumy & Vachon, 2012) ▪ Prioritization of internal or external stakeholders (Chikudate, 2009) ▪ Alignment between operations and strategy (Longoni & Cagliano, 2015)(Wiese, Luke, Heyns, & Pisa, 2015) ▪ Alignment between organization, staff and project objectives (Lapinski et al., 2006) ▪ Technology integration (Ioppolo et al., 2014)(Vachon & Klassen, 2006)
Technology and Decision Support	▪ Technology integration (Vachon & Klassen, 2006) ▪ Technology, 4th sustainability dimension (Ioppolo et al., 2014) ▪ Advanced methods for dealing with complexity (Chuang, 2014)(Ioppolo et al., 2014)(Wang, Huang, Le, & Ta, 2016) ▪ Planning, Monitoring and Evaluation (Susana G. Azevedo, Carvalho, Duarte, & Cruz-Machado, 2012)(Cabral et al., 2012)(Faulkner & Badurdeen, 2014) ▪ Measurement and Metrics (Govindan, Azevedo, Carvalho, & Cruz-Machado, 2015)(Rothenberg, Pil, & Maxwell, 2009)

These 6 thematic categories represent substrative aspects of operations management; the structure of the organization, the context in which it operates, the structure of its workforce, the accumulated knowledge of that workforce, alignment between elements of the organizations and the technologies utilized to facilitate production. At a fundamental level organizations needs to possess sufficient knowledge of sustainability and lean concepts, contexts and tools to drive application (Bergenwall et al., 2012). Considering the complexity of modern organizational contexts and the multi-stakeholder nature of sustainability initiatives means the decision support mechanisms for planning, monitoring and evaluation (Govindan et al., 2015; Rothenberg et al., 2009) are essential to tracking progress and results in implementation; utilizing advanced methods to understand contextual complexity (Chuang, 2014; Ioppolo et al., 2014) and suitable metrics and methods for measurement to facilitate the tracking of performance (Govindan, Jafarian, Khodaverdi, & Devika, 2014). Following from this, the often multifaceted, multi-objective nature of lean sustainability initiatives within complex multi-stakeholder context drives the importance understanding of customer value, in order to establish common areas of value between the organization and its customer as well as for clearly defining perceptions of value between stakeholder within the organization (Koranda et al., 2012). Additionally, the lean literature indicates that developing organizational capacity through the training (Chaplin et al., 2016) and structuring of the workforce is necessary for effective lean sustainability efforts; in this respect consideration for elements of training, teamwork, self-direction and organizational work habits and procedures are important contributors to ensuring the desired outcomes are achieved (Jeffers, 2010). From a strategic perspective, the matter of integrating lean practices, sustainability objectives and supporting technologies are significant explanatory factors driving sustainable performance (Rosenbaum et al., 2014). In this regard, the strategic focus of the organization between internal and external stakeholder, as well as the prioritization between managerial/procedural and infrastructure based interventions need to be considered (Chikudate, 2009; Thoumy & Vachon, 2012). The structure/nature of the organization is itself a significant determinant of lean sustainability performance (Rao, 2004). Factors related to the size and magnitude of the practice, the nature of the suppliers and the customers, organizational culture, site layout and resource availability need to be accounted for. Lastly, the context within which the organization operates, the marketplace complexity, marketplace dynamism, changing customer expectation and diversity of stakeholders in the supply chain need to be factored in when tailoring lean application for the intended context (Cabral et al., 2012).

2.2 Operations Management Primary Production Context

The management of operations in the agricultural primary production context faces a unique set of challenges; in the context of a dynamic marketplace and seasonal production factors; farming systems are complex and have to account for a range of biophysical, technical, socio-economic and policy elements when making production decisions (Louhichi, Alary, & Grimaud, 2004). The efficiency of production from a farm's land, labor and capital is critically dependent on the ability of the farm manager (Nuthall, 2009) and consequently the on farm practices implemented by the grower have a significant bearing on the resultant quality and quantity of food produced, which comprise the primary success factors for agricultural producers (Sivakumar, Jiang, & Yahia, 2011). Food production, processing and marketing systems are complex. In addition to the diverse range of practitioners, operational decisions within farming systems need to account for a multitude of different end-users and stakeholders directly or indirectly impacting operational imperatives (Pla, Sandars, & Higgins, 2014). Followingly, (Archer, Higgins, & Thorburn, 2009) notes that biophysical complexity within the chain increases towards the producer side while management complexity increases toward the retail end of the chain; the implication being that the inherent challenges faced at various points in the chain may differ significantly. The current challenge lies at the producer end, where (Pla et al., 2014) posits that the inherent complexity of these biotic systems and industries can be an obstacle to the applicability of traditional operations research approaches. It is suggested by (Abdel-Malek et al. 1999) that in this field "mainstream OR literature is full of theoretical mathematical models of doubtful real-world utility". Followingly, (Muller-Merbach, 2010) posits that the challenges faced are highly interdisciplinary in the manner in which they draw from various scientific domains and even from social and management theory and could benefit from the adoption of more pragmatic problem-solving approaches (McCown, 2002).

Table 2: Characteristics of the horticultural primary production

Component:	Horticultural Primary Production Characteristics:
Product	▪ Variability in quality and yield of outputs ▪ Variability in quality, supply and price of inputs ▪ Perishable product (growing and once harvested)
Production Process	▪ Seasonal batch production (Production rate is mainly determined by area under cultivation) ▪ Variable yield and growth duration (Varying according to varietal) ▪ Cultivation recipe varies according to varietal ▪ Labor intensive, requires meticulous approach to handling the fruit ▪ Presence of climatic and biophysical risk factors
Plant	▪ Variability in production context (Rainfall, pests, temperature, etc.) ▪ Presence of climatic and biophysical risk factors ▪ Layout of production area fixed over the short term

2.3 Lean in Agri Food Context

The literature highlights that the reductions of food wastage and increases in the efficiencies of resource use are key strategic elements driving sustainability in agri-food supply (Davis et al., 2016; Foley et al., 2011), linking neatly with the position of (Colgan et al., 2013) that lean could contribute to efficient resource utilization and also reduce food waste through the protection of production quality. There are a paucity of studies investigating the application of lean management practices in the primary production segment of the agri-food supply chain. A summary of the available literature is outlined in Table 1. Notably, of the available 6 studies, only a single study assumes a farm level perspective, with the remainder adopting a supply chain perspective. The available research identifies several potential benefits including cost savings at various point in the chain (Zokaei & Simons, 2006) and logistical benefits across the chain (Simons & Taylor, 2007). At the farm level (Colgan et al., 2013) points out that growers could benefit from improved quality of output and reductions in operating waste. However, within the agri-food context lean methods face several problematic contingencies and potential obstacles with (Cox et al., 2007) stating that it would be beneficial if further in-depth studies could be undertaken the agri-food supply chain. It is pointed out by (Cox & Chicksand, 2005) that the interorganizational aspects of lean may be challenging to implement; this notion is echoed by (Simons & Taylor, 2007) stating that inter-company alignment of other sub-systems and chain organizational stability through time are key issues to be encountered in this context. An explanation is proffered by (Cox et al., 2007), stating that in the context of a relatively fragmented supply chain, the inherent uncertainty related to how the benefits associated with lean implementation might be distributed among the chain actors, acts as a source of uncertainty, and consequently as a barrier to implementation. That being the case, (Colgan et al., 2013) does posit that lean efficiency and quality effectiveness could be extended to various farm models to improve farm performance.

Table 3: Overview of Lean Agri-Food Literature

Author:	Method:	Findings:	Objective of Lean Implementation:	Limitations/Recommendations:
(Cox & Chicksand, 2005)	Case Study, Red Meat Supply Chain	▪ Internal lean practices may be appropriate for the red meat supply chain ▪ Inter-organizational aspects of lean may not be easy to apply in practice	▪ Increase competitiveness and profitability in the UK food industry and red meat supply chain	▪ Study limited to beef supply chain
(Zokaei & Simons, 2006)	Case Study, Red Meat Supply Chain	▪ lean production techniques report 2- 3% potential cost savings at each stage of the chain ▪ Suggests that there are benefits from applying Lean Principles to a farm business in terms of reducing waste and improving the quality of food supply	▪ Contributing element in a push to minimize the cost of supply	▪ Exposition limited to two lean concepts
(Taylor, 2006)	Case Study, Red Meat Supply Chain	▪ In contrast to the vision of a dedicated and integrated chain, current pork chains tend to be fragmented at various levels ▪ There is a need develop a joint understanding of the end-user requirements so that all players in the chain can work towards providing customer value	▪ Improve integration of the chain to drive greater chain efficiency	▪ Study limited to two supply chains, both pork. ▪ Recommends expanding to other food SC's
(Simons & Taylor, 2007)	Case Study, Red Meat Supply Chain	▪ Positive logistic benefits across the chain. ▪ Identified two key implementation issues; inter-company alignment of other sub-systems and chain organizational stability through time.	▪ Main objective is to improve performance and profitability of the chain	▪ Study limited to three supply chains, beef, lamb and pork ▪ Recommends expanding to other food SC's
(Cox et al., 2007)	Case Study, Red Meat Supply Chain	▪ Red meat supply chain has very different demand, power and supply characteristics in comparison to automotive SC ▪ These characteristics impact the benefits the different supply chain actors derive from lean	▪ Lean methods in the supply chain (farm gate to consumer) seeking to drive improved commercial performance of the chain	▪ This study is limited to three red meat supply chains; beef, lamb and pig. ▪ Recommend further in-depth studies could be undertaken in other agri-food SC's
(Colgan et al., 2013)	Case Study, Farm Level, Value Stream Mapping	▪ There are benefits from applying Lean Principles to a farm business in terms of reducing waste and improving the quality of food supply ▪ For Lean to be successfully applied farmers need to be acquainted with the principles of Lean	▪ Reduce waste and improve quality of food supply	▪ Recommends expanding case analysis to other farm models

3. Design and Methods

This case study is part of an ongoing applied research project by a team of lean manufacturing and operations management experts from Belgium, the United Kingdom and South Africa. A sizeable horticultural cooperative based in the Western Cape of South Africa is the central focus of this case study. The cooperative in question oversees close to 6000 hectares of commercial apple and pear production, serving both local and international fresh produce markets. The cooperative extends its ownership across a forward integrated supply chain that includes cold storage, packing, packaging, logistics as well as product marketing and sales divisions. With reference to the use of the phrase "forward integrated supply chain", vertical integration is described as forward integrated when it is initiated at or near the raw material stage of production (Fred-Koller, 1950). For the purposes of framing the ensuing narrative this study assumes, as a point of departure, the functional definition of sustainability outlined by (Carter & Rogers, 2008) who states that a sustainable organization is an organization that understands and manages the economic, environmental and social risks resulting from its operations.

The single case method is employed to conduct a detailed and nuanced description and analysis of the lean operations management methods employed in support of the intensive horticultural production of apples and pears. The decision to adopt this approach was based on the position of (Yin, 2013) who states that this case study method is most suited to an assessment of contemporary events over which the researcher has little or no control, resting on (Becker, 1970)'s key assumption that in this instance it is possible to acquire knowledge of the phenomenon from the intensive exploration of the individual case. This approach is supported by (Ghauri & Grønhaug, 2005) who recommends that the case study strategy be utilized when "how" or "why" questions are being asked. There are however, several criticisms of the single case method. The most prominent concern, that related to the susceptibility of the approach to an absence of systematic procedure (Yin, 2013) is addressed through the adoption of a rigorous methodological approach which is delineated in this chapter. The second concern which is related to the susceptibility of the approach to researcher subjectivity and personal validation effect (Eisenhardt, 2016) is addressed through the use of multiple sources of evidence including interviews, direct observations and secondary sources of information. This follows (Diesling, 1971) who recommends compensating for personal validation effect by rechecking and validating interpretations through comparisons of different kinds of evidence. Additionally, several steps were taken to support the reliability of the study including the utilization of a single interviewer to maintain consistency, the documentation of research steps and processes as well as development of a chain of evidence (Yin, 2013).

The initial step toward addressing the overarching research objective involved conducting a systematic review of the literature to identify the determining factors shaping the linkages between the application of lean methods and the attainment of sustainable performance outcomes. A comprehensive search was conducted on the "Web of Science" database identifying papers addressing the topics of both "lean management" and "sustainability"; following the exclusion of books and conference proceedings an initial batch of 143 papers was identified. This initial batch of papers were analyzed to identify their specific consideration of (a) economic sustainability, (b) environmental sustainability and (c) social sustainability. Papers addressing at least two of these three topics were included, whilst the remainder were discarded. Thus, after abstract and full article screening, a total of 62 articles were selected. The rational for this decision, is to consider only those papers which address the overlap, integration or simultaneous pursuit of these three sustainable performance facets. Following the approach set out by (Thomas, Harden, Thomas,James, & Harden,Angela, 2008), the selected literature was subjected to thematic analysis to identify key recurring themes related to determining factors that relate lean methods with sustainable operational and supply chain performance. The specific determining factors identified, have been thematically grouped and summarized in Table 1, shown earlier in chapter 2.1.

Following the approach set out by (Dora et al., 2015), the study is framed by the Practice Contingency Research (PCR) approach first put forth by (Sousa & Voss, 2008); a model which was later adapted by (Dora et al., 2015) to guide exposition on determinants of operational performance driven through the application of lean methods in the food processing industry. The model stipulates that a robust model in the field of operations management needs to account for a) the practices selected, b) the performance achieved and c) the determining factors relevant to these elements (Dora et al., 2015; Sousa & Voss, 2008). The benefit of this approach is that it provides a unifying conceptual foundation through which to bound the narrative of the case study and the subsequent discussion thereof. Additionally, although the PCR approach is heavily based on the contingency paradigm (Sousa & Voss, 2008), the model may be adjusted to include varied theoretical perspectives, allowing for the incorporation of non-efficiency based paradigms such as institutional theory (DiMaggio & Powell, 1983) (i.e. seeking legitimacy) or strategic choice theory (Child, 1972) (i.e. accounting for free managerial choice). Within the context of this study however, this approach does not negate any of the limitations inherent in the case study approach. Finally, the model framework, as evident in Figure 1, is further adapter to incorporate a continuous improvement mechanism, representing the dynamic and ongoing cycle of practice adaptation. Practices specified in the model adopt the stipulation by (Sousa & Voss, 2001), and later (Dora et al., 2015) which specifies that lean may be summarized into sets of specific lean practices related to internal operations, supplier related practices and customer related practices. This study incorporates 11 sets of practices, which are used to frame our investigation and are specifically 1) involved customer, 2) supplier feedback, 3) just-in-time (JIT) delivery, 4) developing suppliers, 5) pull, 6) flow, 7) low set up time, 8) controlled processes, 9) preventative maintenance and 10) involved employees and 11) visual management. The final set, visual management, represents a new addition to the model outlined by (Dora et al., 2015).

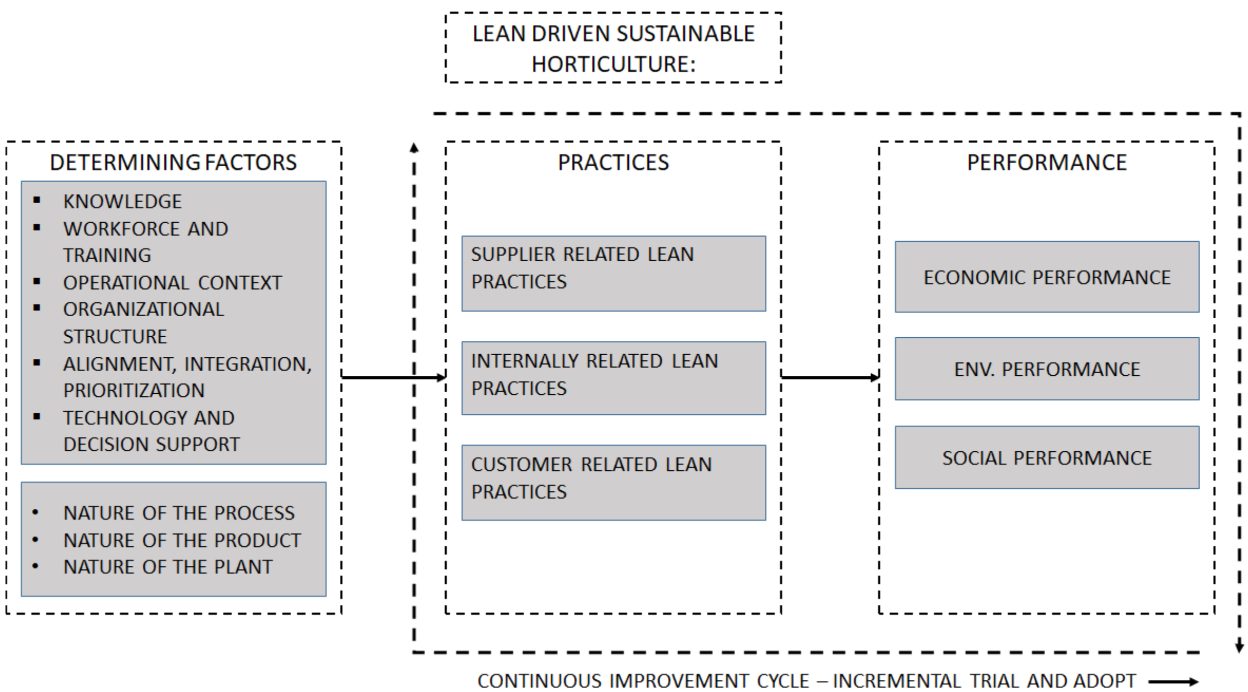

Figure 1: Research Model - Integrated Lean Sustainability Practice Performance Model (Adapted from (Dora et al., 2015)*)*

An interview guide was developed based upon the key literature elements outlined in Figure 1, Table 1 and Table 2. The interview guide was field tested and refined through a pilot study and expert review conducted prior to the commencement of the main data collection phase. As per the recommendation of (Becker, 1970) field testing supports flexibility in the case study approach, allowing the investigator to prepare for unexpected factors and to reorient his study considering such developments. Additionally, the structure developed for the interview guide doubled as a framework around which the findings could be analyzed and over a which the narrative of chapters 4 and 5 could be developed. As is stated by (Saunders et al., 2007) the use of qualitative methods such as semi structured interviews are most suited to exploratory research of this nature. A total of 25 interviews were conducted with horticultural estate managers (the growers), cooperative technical and managerial staff as well as with key public and private sector support stakeholders. Processes taking place downstream in the supply chain have a significant bearing on primary producer decision making processes, and thus it was deemed essential to incorporate these elements into the investigation and analysis, though the central focus of the case remains squarely on its relevance to the primary production segment of the chain. These semi-structured interviews, approximately 45 to 90 minutes in length, were carried out in addition to direct observation (Gemba walk) of the cultivation and production areas and processes. Related documentation and other sources of secondary information were collected from the interviewees themselves, from relevant public and private sector bodies as well as from other publicly accessible sources of sector information. From these various sources elements of numerical data are also incorporated into the study.

4. Case Analysis

This case study provides exposition on the use of lean methods to drive sustainable performance in the horticultural production of apples and pears. The case considers the strategies and operational tactics of 4 apple and pear growers, hereafter referred to as growers A, B, C and D. These growers exist as members of two prominent apple and pear agricultural cooperatives located in the Ceres District (Growers A and B) and in the Elgin District (Growers C and D) of the Western Cape of South Africa. These districts, separated by a distance of over 100km, are endowed with suitable conditions to produce apples and pears, collectively accounting for almost 6000 hectares under cultivation. Both the Ceres and Elgin based cooperatives build their strategic advantage through alignment and control across a forward integrated supply chain which incorporates primary production, storage, packing and packaging, logistics and product marketing and sales. The 2 cooperatives, which are grower owned, are co-owners of this forward integrated supply chain and thus, for the purposes of this study, they are treated as a single group. Quality is cultivated on the farm; once an apple or pear is harvested, its quality cannot be improved upon. The onus is thus first and foremost on the growers to produce top quality fruit. Beyond the farm gate, the other elements of the forward integrated supply chain exist to preserve the quality of that fruit, ensuring that it is delivered in a cost-effective manner. Followingly, the supply chain strategy is centrally designed around grower operations and is designed to best fit the needs of the growers.

- Write about how lean tell-tale sign are in the South African fruit sector…

Within the South African apple and pear horticultural subsector, cultivation practices are largely conventional. Intensive irrigation and fertilization is standard practice, necessary to achieve consistent quality and yield in production. Orchards require careful maintenance throughout the year, and are subjected to manipulation, pruning, thinning and various pest maintenance measures. Harvested apples and pears are transported to a central packhouse, where the produce is graded, sorted, packed, stored and eventually shipped. Quality of produce is a major order winner and profitability factor for agricultural producers; harvested produce, dependent on quality, will be directed to one of three destinations, export markets, local markets or processing plants for juice, aroma and pulp extraction, drying, etc. The integrity of the cold chain is central to preserving the quality of the produce from the point of harvest through to the point of purchase and consumption. Fresh Apples and pears moving along the chain must face a range of issues related to handling and storage to control for perishability, limited shelf life and the alignment of produce availability to periods of optimal demand.

With a customer centric view on value creation, a tight focus on waste reduction and a subsector wide push to promote continuous improvement in sustainable grower and supply chain operations, several factors that (Cherrafi, Elfezazi, Chiarini, Mokhlis, & Benhida, 2016b; Hallgren & Olhager, 2009) recognizes as drivers of lean diffusion and adoption are present within the investigated context. A key point of emphasis highlighted by several of the interview respondents is that within the apple and pear horticultural subsector, continuous improvement in the sustainable performance of grower operations is necessary to remain competitive in the evolving global marketplace. Followingly, growers specifically look toward 3 factors, the maximization of crop yield, the reduction of food waste and the increased efficiency of resource use in production as the solution to their challenge, mirroring what (Foley et al., 2011) specifies as the three producer side pillars driving greater sustainable performance in agricultural production. Within these 3 key areas growers look toward the adoption of innovative practices and technologies to drive progress. However, it was severally stated that due to the overwhelming abundance of information and innovation options available, and limitations on available time to consider those options, that growers relied heavily on the cooperative's in-house technical expertise as well as expert 3rd party service providers to advise on possible avenues of innovation, including those that shape operational and supply chain managerial approaches. The technical experts based with the cooperative highlighted that due to the numerous sources of uncertainty in the primary production environment, that growers tended to be quite risk averse toward the adoption of new innovations, preferring rather to incrementally trial new approaches before adoption; "They take what works, and leave the rest.". It was emphasized that this approach enabled growers to test for unexpected interactions between a new adoption and the operational environment, allowing them to take on risk in manageable increments.

Followingly it was stated that new innovations took time to gain acceptance within the group, but that new methods or technologies that were proven to produce results reliably, quickly diffused among the growers via internal technical and relational channels. Evidence similarly pointed toward the selective and incremental diffusion of lean methods within the group, though in this regard two point-sources of diffusion were identified; firstly, through expert 3rd party service providers comprising both privately operating sectoral consultants as well as academics based with regional higher education institutions, and secondly through accredited sectoral training and education structures, which include the aforementioned higher education institutions. Evidence indicates the first of these avenues to the most influential in shaping the lean configuration of practices within the group. Training and education efforts are largely targeted toward the development of technical and bioscientific proficiencies, a domain in which the group retains a remarkable depth of talent. Although the development of managerial skill sets within the group is given priority, the focus within this area, on paradigmatic operations and supply chain management content (i.e. lean, agile green, etc.), is relatively narrow.

The overarching cooperative structure plays a far more deterministic role in shaping the lean in shaping group operational practices, and in particular they employ 3rd party experts to advise on a shape evolving operating structures. Although individual grower operations are management according to the style of the estate management, there is a group requirement to integrate with the overarching cooperative system of management, resulting in the homogeneity of practices in regard to specific underlying operations and supply chain processes and procedures. The results of these structures and processes is a lean configuration of practices that is probably more emergent that it was predetermined. Resulting in system of practices that is highly integrated with traditional farm management approaches, that is highly functional at reducing waste, yet lacks many of the superficial qualities of a traditional lean system. The evidence thus points toward the emergence of lean methods in grower operations as being reflective of the evolutionary nature of the agricultural practices employed, the nature of the relationships between members of the cooperative and the suitability of lean practices to facets of the primary production context.

The interview respondents emphasized that a lean and efficient grower operation starts with a well-developed relationship of trust with the customer and a well-developed understanding of the attributes that they value in a supplier. A key challenge faced by primary producers relates to that of push production, where there is no link between production and consumer demand (Taylor, 2006). The group addresses this challenge using a forward contracting process whereby buyers place preliminary orders for their apples and pears a year in advance with an adjusted final order cemented a few weeks before expected delivery. This forward contracting process combined with sales forecasts provides the group with a detailed demand schedule for the upcoming 12 months. The 12-month demand horizon is significant from a technical standpoint because within a seasonal annual production cycle it is at this point that one is switching emphasis from push production toward a pull production system. Although, there is an inherent level of flexibility in these processes, on both the buyer and supplier side, the respondents pointed out that risks associated with this flexibility are largely mitigated through conservative production planning and through a portfolio effect resulting from the maintenance of a diverse buyer portfolio. The 12-month planning horizon allows growers to plan production objectives for the upcoming cycle, in a process of strategic alignment between growers known as crop programming.

Crop programming is the process by which the cooperative aligns the productive capacity of the growers with the demand characteristics of the market. Crop programming considers the collective productive capacity of the growers for a range of cultivars, assessing this productive capacity relative to market demand, for specific cultivars, for a range of export and local markets over the coming period. In-house technical personnel work alongside the growers to set production targets and align these targets across the group. This process addresses both short term (< 1 year) and long term (> 1 year) alignment factors. In the short-term growers must work with their currently available orchard stock, over this period output can be adjusted to a degree by varying the inputs of labor (including pruning, thinning and picking), irrigation, chemical fertilizer and other supporting factors. In the longer term however, growers need to consider the ongoing relevance, health and lifespan of their current orchards, as well as the development of new growing capacity. In certain instances, a grower might retire an aging orchard early to make way for new stock. Over time, subject to the limitations of land and other inputs, growers can and do adjust the size and composition of their orchards to suit evolving needs and tastes of the market.

Table 4: Operational Summary of Growers A, B, C and D

Cooperative Structure:	Ceres Region		Elgin Region	
	Grower A	Grower B	Grower C	Grower D
Cultivating: Other: Area Under Cultivation (Apples and Pears):	▪ Apples, Pears, ▪ Vegetables ▪ 130 Hectares	▪ Apples, Pears ▪ N.A. ▪ 160 Hectares	▪ Apples, Pears ▪ Kiwis ▪ 35 Hectares	▪ Apples, Pears, ▪ Other fruit, Beef, Pork ▪ 350 Hectares
Strategic Priorities:	▪ Improve labor productivity ▪ Deeper tech integration ▪ Long term family business perspective	▪ Implement prod. controls ▪ Deeper tech integration ▪ Optimize bin, tractor and loading	▪ Maintain high quality, push yield ▪ Find simple tech solutions ▪ Controlling costs	▪ Fine tuning harvesting methods ▪ Orchard densification ▪ Research and innovation

Growers seeks to maximize the yield and quality of their crop. In line with the position of (Stanley et al., 2000) respondents indicated that the successful marketing of apples and pears is critically dependent on supplying the right cultivar, sufficient volumes of those cultivars, good fruit quality and size. In particular, top quality produce that meets the necessary size, color and taste requirements for the international export market fetches approximately double the price, per given weight, in comparison to produce sold to local markets or fruit processors (Hortgro, 2016; Lötze & Bergh, 2004), making the production of 1st class export quality fruit a top priority for South African growers. However, and quite importantly, quality of produce is not the only requirement for export market access. Growers are facing increasingly stringent market entry standards, where fruit destined for various regions is required to meet specifications not just for the quality of the produce, but also for the suitability of the manner in which that produce is cultivated, i.e. growers are increasingly required by buyers and regional access regulations to adhere to specified environmentally sustainable and socially ethical standards of practice. Moreover, further, these practices are required to be conducted in a manner that is transparent, traceable and verifiable either through independent third-party accreditation or directly by the buyers themselves. It was noted by respondents that environmentally sustainable and socially ethical standards of practice were now largely ubiquitous across both local and export markets, though the stringency of those standards varies from market to market. Additionally, it was severally stated that it is according to these specified standards of production that the growers parameterize the sustainable performance of their operations.

Followingly, the group asserts its position as market leader within the South African Apple and Pear industry by maintaining superior performance in three domains; fruit yield, fruit quality and operational sustainability (i.e.

environmentally sustainable and socially ethical standards of practice). Benchmarks established by the Bureau for Food and Agricultural Production (BFAP, 2016) highlight that among South African producers a varietal dependent yield for a typical apple orchard is broadly between 55 tons ha^{-1} and 80 tons ha^{-1}. Similarly, varietal dependent benchmarks of pear production in South Africa show that typical orchard yield lies between 45 tons ha^{-1} and 70 tons ha^{-1}. In comparison the groups' technical departments report that their growers, subject to variable growing conditions, achieve consistently good yields at the upper end of these scales. They assert that, in the case of apple production, high-yielding full-bearing orchards may achieve outputs of between 80 tons ha^{-1} to 100 tons ha^{-1}, whilst top performing orchards might achieve yields as high as 120 tons ha^{-1}. Similarly, high yielding full-bearing pear orchards, subject to variable growing conditions, may obtain outputs of between 70 tons ha^{-1} to 80 tons ha^{-1} whilst top performing pear orchards may exceed even that. In terms of achieving operational sustainability, the group assumes a highest common denominator approach to standards of production; i.e. although degrees of stringency vary across markets, the group seeks to meet and exceed the strictest of standards specified by their portfolio of buyers, thereby ensuring market access across the board. Moreover, these standards of production are verified through a system of 3rd party accreditation, with grower operations facing annual operational audits to ensure ongoing compliance. The environmentally sustainable and socially ethical standards of practice are evident in the accreditation and successful audit compliance status of each of the growers that comprise the group. These standards of sustainable production in combination with the groups high fruit quality are evident in their export market access figures, as the group maintains a portfolio of buyers across more than 100 nationalities worldwide, and they consistently export between 65% and 70% of their produce to this international market; in contrast to statistics for the sector which indicate that on average 44% of apple output and 49% of pear output is exported (Hortgro, 2016).

In addition to the maximization of crop yield and quality, growers also seek to minimize food waste and to optimize use of inputs to production. Food waste is viewed from 2 perspectives. Firstly, in terms of on-tree fruit that are harvested prematurely, or which never reach 1st class specifications; the proportion of lower grade fruit grown remains a key inefficiency in production. Secondly, in terms of cultivated fruit that have reached 1st class specifications, but that are damaged or rendered otherwise unsellable somewhere between the point of harvest and the point of final delivery to the buyer. Five key inputs to production (i.e. cost drivers) are highlighted by the growers, including labor, energy, fertilizer, other chemical inputs and supporting farm services (which includes external consulting, administrative and managerial costs). Comments from the growers and cooperative technical staff alike highlighted that inputs to production were relatively inflexible, stating that quantities of chemicals utilized, irrigation applied, energy consumed, and labor utilized were treated as being relatively inelastic. Hence for growers the concept of waste reduction very much emphasizes maximizing yield and quality of produce for a given level of productive inputs as opposed to reducing inputs relatively to a given level of production. Significant emphasis is thus placed on improving the efficacy of productive processes which in turn are assessed in terms of the yield and quality of fruit produced. Additionally, respondents highlighted that labor and chemical inputs (incl. fertilizers, pesticides, etc.) collectively comprise as much as 70% of total operational costs; hence grower's particular emphasis on the effective management of these inputs.

Although each of the four growers detailed in this case demonstrates functionally homogeneous production processes, each achieves its respective performance objectives through a slightly different strategic approach, reflecting the unique characteristics of each grower operation. Table 4 outlines basic specifications and strategic priorities for each of the four growers listed in this case. Grower C, the smallest of the four, employs a hands-on people-oriented approach to farm management. The estate manager pointed out that the relatively small size of the operation allowed him to maintain a good presence out in the orchards and to know first-hand how operations are progressing. He stated that the operation was achieving good fruit quality, but that they were now shifting emphasis toward increasing the yield. It was also emphasized that the small size of the operation meant that they don't benefit from scale as with many of the larger growers, and thus had to maintain a constant lid on operational costs. Also located in the Elgin District, Grower D is the single largest grower in the group and stands in stark contrast to Grower C. Its 350 hectares of apples and pears form part of a mixed production estate almost 1900 hectares in size. The estate is run by a team of managerial and agricultural professionals, with a division dedicated to fruit production. The operation boasts fully integrated ERP and crop management systems, research orchards and an operational philosophy based upon the "right first time" principle. Growers A and B, based in the Ceres District, fall somewhat halfway between Grower C and D in terms of their scale of operations. Although more scale oriented than Grower D in terms of operational priorities, neither displayed the same level of technological integration as Grower C. A key characteristic of Grower A is that the estate is family owned and operated, a factor which is evident in their managerial ideology and long term strategic perspective. From an overarching perspective, the growers listed three general factors as being a necessary foundation for achieving a lean operation including proper care and maintenance of orchards to maximize yield and quality, appropriate harvest protocols and quality controls to ensure minimal fruit damage during harvest and a well-trained and organized body of staff to implement the day to day specifics of running operations.

Table 5: Key factors/elements driving a sustainable lean growing operation

Company:	Key Factors or Decisions:
Grower A	▪ Experience and knowledge of the orchards in which they work ▪ Skilled and motivated team leaders (supervisors and foremen) to manage work in the orchard. ▪ The level of education among most of our laborers can limit their teachability ▪ Keeping records, you must have close records of all activities, then managing the operation. We can't be everywhere in the orchards all the time, so the records are essential to keeping the big picture in sight. ▪ We record everything, more or less everything. The earned wage, of each worker, for each day, every day, for the working year; every orchard, and the amount of man hours and money spent to operate that orchard. ▪ High level of detail and consideration in maintaining orchards, we use the most appropriate approach for each tree ▪ Spending time in the orchards. Every day, I walk with the foremen in the orchards, that way we pick up very quickly where the issues are
Grower B	▪ Quality of your foremen is a big factor, as they are your eyes and ears in the orchards. They are also the most important communication channel to the workers. ▪ Staff days and special staff camps (separate camps for the men and women) to boost moral ▪ Increasing use of technology to manage all this information on a day to day basis ▪ Value driven decision making.
Grower C	▪ Relationship with coop is source of advice for difficult/complex problems on the farm ▪ We have good fruit quality, because we are a relatively small operation, so it is relatively easy to manage the details. But, now we are trying to push the yield of our trees, ▪ Two stage quality control, first in the orchard, and then again before being loaded for transport to the pack house ▪ Being a relatively small operation, we rely on the cooperative to advise/support our compliance with labor and environmental regulations
Grower D	▪ Right first time operating principle ▪ Perfect timing of orchard activities, manipulation, pruning, thinning and the application of chemicals ▪ Don't just blindly follow operating plan, always keep one eye open, read the orchard, and adjust as necessary ▪ Evidence based controls and monitoring at all key phases in the process ▪ Incentive structure built on top of basic wage to motivate high performance ▪ Working toward denser (more trees) orchard, with lower yield but higher quality per tree ▪ Maintaining exposure to new ideas and development in the sector, internationally.

Fruit farming is a labor-intensive process and growers like to be able to "see" what is happening in the orchards. However, due to the geographically distributed nature of grower operations, managers rely on their workforce, particularly their supervisors and foremen to be their "eyes and ears" out in the orchards. Consequently, growers place an enormous amount of importance on the capacity of their workforce to act independently and effectively. Growers stated that it can take a considerable period for a worker to acquire the skills necessary for pruning, thinning and harvesting. The development and retention of specialist managerial, technical and scientific skill sets was also noted as being an important driver of sustainable performance in operations. The development and growth of agricultural related research into the areas of cultivars, grower's methods, irrigation practices, pest management and so on, have been a major contributor to the growth in yield whilst reducing comparable levels of

Table 6: Summary of lean determining factors and critical point of attention.

Focal Area:	Determining Factor (DF):
General Farm Management:	DF1: Production area is geographically vast and distributed DF2: Orchards require careful care and maintenance to maximize yield and quality DF3: Knowledge and awareness of lean management principles and practices remains limited DF4: Growers face overwhelming amount of information and decisions DF5: Growers, who already face many sources of dynamism, are highly risk averse DF6: Highly dynamic climatic factors present risk to production (precipitation, temp. etc.) DF7: Highly dynamic biophysical factors present risk to production (pests, contaminants, etc.) DF8: Farm workers face challenging domestic contexts, low levels of literacy and language barriers DF9: Teams of farm laborers required to operate swiftly and independently DF10: Growing importance of research and innovation to remain competitive
Harvest Process Management:	DF11: Process for picking fruit is physically demanding and requires a trained eye to select suitable quality fruit (i.e. suitable size, no bruising, sunburn or pest damage, etc.) DF12: Seasonal and batch production DF13: Rough handling/transport may damage fruit between point of harvest and storage DF14: Fruit is perishable and has a limited shelf life
Downstream Elements:	DF15: Quality of produce is a major order winner and buyers specify exacting quality specifications D16: Fruit varietal preferences, taste and quality specifications vary between markets DF14: Capacity for innovation is proportional to the scale of the grower operation DF18: Specialist skills (operations management, pest management, etc.) critical to innovative capacity of the group DF19: Fruit needs to be traceable to point of origin DF20: Buyers specify exacting environmental and socially sustainable standards of production DF21: Downstream elements pushing for greater alignment with primary production practices DF22: Drive/need for continuous improvement to stay sustainably competitive in global market

Action / Response:	Critical Point of Attention:	Lean Objective and Link to Literature:
▪ Forward planning for production period with constant adaption to changing conditions	▪ DF2, DF6, DF7, DF15, DF16	▪ Flow (Colgan et al., 2013; Cox & Chicksand, 2005)
▪ Getting into orchard to view operations first-hand	▪ DF1	▪ Gemba (Rothenberg, 2003)
▪ Regular (weekly) feedback and adjustment meetings between management and foremen	▪ DF2, DF6, DF7	▪ PDCA driving strategic/operational alignment (Longoni & Cagliano, 2015)
▪ 1st stage quality control at point of loading + immediate feedback to workers in orchards	▪ DF11, DF13, DF15, DF21	▪ PDCA (Chaplin et al., 2016; Sagnak & Kazancoglu, 2015)
▪ 2nd stage quality control at pack house + feedback to grower	▪ DF11, DF13, DF15, DF21	▪ PDCA (Chuang, 2014; Sagnak & Kazancoglu, 2015)
▪ Incentive linked to performance	▪ DF11, DF13, DF15, DF21	▪ Motivated and involved employees (Longoni et al., 2014)
▪ Customer 12-month ahead pre-orders + demand forecast	▪ DF12, DF14, DF16, DF21	▪ Developed Customer & Pull (Colgan et al., 2013)
▪ Growers subjected to regular performance audits and participate in practice benchmarking	▪ DF15, DF20, DF22	▪ Continuous improvement - through auditing/benchmarking (S. G. Azevedo, Carvalho, & Cruz-Machado, 2016)
▪ Preventative maintenance/care for farm equipment and farm orchards	▪ DF6, DF7, DF9	▪ Preventative Maintenance (Rothenberg et al., 2009)
▪ Training and development, bursary provision for promising individuals	▪ DF3, DF4, DF8, DF9, DF10	▪ Motivated and involved employees (Chaplin et al., 2016)
▪ Use of technology to support the management of complex and dynamic production environment	▪ DF1, DF2, DF6, DF7, DF10, DF19, DF21	▪ Flow, Perfection - through technology (Ioppolo et al., 2014)
▪ Moral building activities for farm laborers	▪ DF8, DF9, DF10, DF20	▪ Motivated and involved employees (Chaplin et al., 2016)
▪ Specialist 3rd party services providers advise on managerial approaches, technology adoption and sustainability standards and practices	▪ DF3, DF4, DF10, DF18	▪ Perfection - through knowledge (Rothenberg, 2003)
▪ Incremental "probe and adopt" approach to production process innovation	▪ DF4, DF5, DF6, DF7	▪ Reduced risk path to process innovation suited for dynamic environments (Cole, 2002)
▪ Supporting services (schooling + medical) provided to farm laborers and their families	▪ DF8, DF11, DF20	▪ Motivated and involved employees (Jarebrant et al., 2016; Wong & Wong, 2014)
▪ Downstream marketing and sales departments advise on specific buyer quality specifications	▪ DF4, DF15, DF16	▪ Identifying value in dynamic consumer environment (Sekar et al., 2015)
▪ Technical departments advise comprehensively on sustainability standards and practices	▪ DF4, DF20, DF21	▪ Identifying Value (Dutt & King, 2014; Koranda et al., 2012)
▪ Technical and logistical departments advise on supply chain practice alignment	▪ DF4, DF20, DF21	▪ Flow (through alignment) (Lapinski et al., 2006; Longoni & Cagliano, 2015)
▪ Multilingual foremen act as bridge between management and farm workers	▪ DF8, DF9	▪ Gemba, Involved Employees, Teamwork (Pagell et al., 2014; Rao, 2004)
▪ Foremen act as "eye and ears" in the orchard to support managerial awareness of conditions	▪ DF1	▪ Involved Employees, Teamwork (Pagell et al., 2014; Rao, 2004)
▪ Bigger coop farms take the lead in conducting research into innovative practices and technologies	▪ DF4, DF5, DF6, DF7, DF10, DF14, DF22	▪ Reduced risk path to practice innovation (Thoumy & Vachon, 2012)
▪ Use of satellite (decentralized) loading bays	▪ DF1, DF13	▪ Flow through redesign of site-layout (Wu et al., 2013)(Lapinski et al., 2006)
▪ Visual cue used to signal process progress at centralized points of operation	▪ DF1, DF2, DF9	▪ Flow / Kanban (Folinas, Aidonis, Triantafillou, & Malindretos, 2013)(Lewis, 2000)

production waste including water, energy (diesel and electricity), emissions, pest management and chemical inputs. The critical mass of the cooperative has stimulated the emergence of a supporting pool of specialist service providers who exist alongside the group in mutually beneficial symbiosis. The group retains in-house specialists where their business model allows, but for all other instances this pool of specialists is available to provide services when necessary. These specialist operators are contracted on an ad hoc basis by the cooperative or by individual growers and undertake a range of value adding tasks including legal and financial services, pest control, training and staff development, trialing of new technologies and other specialist services.

Statistical controls are utilized to assure fruit quality specifications are met during harvest time. Fruit is subjected to a preliminary sort at the point of harvest and a sampled quality inspection at the point of loading. The detailed quality specifications of the sample are immediately relayed back to the harvest team so that adjustments might be made to the harvest approach. Picking teams are incentivized to adhere to fruit specifications through a wage incentive linked to the resultant quality. Grower are likewise experimenting with variations in the harvest processes to improve labor efficiency and reduce damage to fruit. Growers B and D are trialing an on the ground harvest bin system that has shown good results in reducing fruit damage during harvest. Growers hypothesize that having the bin closer to the ground (i.e. not loaded on a trailer) allows pickers to be gentler when tipping their fruit into the bin. Also, Grower B has implemented a decentralized loading system, using 3 satellite loading platforms at optimal points around the farm. He notes that utilizing this system has reduced harvested fruit damage by reducing the distance between the point of harvest and the point of loading; additionally, it was highlighted that "visual message boards" are located at these central loading points to keep workers abreast of progress on specific ongoing tasks.

Several respondents pointed out that the cooperative is currently also looking toward variations in orchard structure to reduce waste in several key areas. Adaptations in the shape, height and width of rows of trees has been shown to allow for the use of more efficient picking platforms which reduce strain on workers and which correspondingly allow for the use of smaller more efficient tractors, facilitating reduced emissions and diesel consumption. Additionally, it was highlighted that the use of smaller tractors in the future would in turn allow for narrower orchard lanes, permitting a denser planting of trees per hectare. Practitioners in the sector are acutely aware of the evolving role of technology, and its role in driving sustainable performance. Followingly, growers and cooperative employees take a very wide view of technological application, pointing out that technology has shown potential application across a range of organizational functions. Growers demonstrated several applications of ICT's to orchard operations, including digital scanning of orchards and produce, integrated digital farm management systems, a mobile app to manage orchard irrigation systems and the use of remote sensing data to drive irrigation and chemical application decisions. Moreover, biotechnologies in the form of new varietals and rootstocks were highlighted as being central contributors to improvements in both yield and quality of produce.

Whilst technological innovation is viewed as being central to driving sustainable performance, growers highlighted the necessity of incremental trialing and adoption of new innovations, as well as the importance of developing the workforce alongside innovation adoption. It was noted that innovation in one aspect of orchard operations often cascaded into practices in other operational areas, and that for future improvements in the sustainable performance of horticultural operations, growers would have to think very broadly about a redesign of the basic structure and operational approach in the orchard. Grower D provided exposition to this point, stating that orchard densification would probably be the most significant area of innovation in coming years, but that the implementation of that kind of innovation would have a cascading effect on a range of standard orchard practices. Narrower orchard lanes and smaller trees will allow for smaller tractors and smaller harvest platforms, which in turn will accommodate more efficient and labor friendly orchard practices. An important point highlighted by the respondents, is that given the 20 to 25-year lifespan of an apple or pear tree, such changes would have to be introduced incrementally, and would take a fair portion of time to implement comprehensively.

5. Results and Discussion

The following section discusses the presented case with regard to the determining factors that either enable or obstruct agricultural primary producers in their pursuit of lean sustainable operations. A wide range of factors outlined here may have a significant bearing on the outcome of these efforts, however assessing the role and impact of these determining factors relative to the unique context of intensive horticultural primary production offers valuable new lessons and insights. In agriculture, there are a many different end-users and supply chain stakeholders that directly or indirectly affect the decision making process of the growers (Pla et al., 2014). The multi-stakeholder approach adopted by this study thus serves to provide us with detailed insight into the strategic and operational considerations of the growers in the context of this multi-stakeholder, integrated and coordinated production context.

5.1 Alignment, Integration and Prioritization

The literature highlights the importance of strategic alignment in driving lean sustainability, where alignment is defined as being the process by which the organization links its structures and resources with its strategy and business environment (Rosenbaum et al., 2014; Wong & Wong, 2014). Our case affirms the importance of strategic alignment in driving lean sustainability, at both the level of the organization and at the level of the supply chain. The respondents highlighted that crop programming and grower consultation programs were two key processes through which the cooperative aligned the efforts of the growers and other supply chain elements. Additionally, the literature identifies operational integration as being an important strategic contributor to lean sustainability, stating that the degree to which organizations are able to integrate and implement strategic objectives and operational practices directed at driving sustainable performance are a direct determinant of the performance of those efforts (Wiese et al., 2015; Yang, Hong, & Modi, 2011).

"Many of the methods and approaches used by the growers to make their operations more sustainable have been adopted little by little over time. Usually something is tested out, on a small scale by a few growers, and if they find success, the approach might be passed on to their neighbors or others in the group."

Overall, the case reveals that lean methods and lean thinking are approached by the cooperative and by the growers as an informally accumulated set of legitimized practices rather than as a formally adopted set of practices. Whilst (Bergenwall et al., 2012) posits that the depth of lean implementation influences sustainability outcomes attained, it may also be argued that an incremental approach to practice adoption may be more suited for the context of intensive commercial horticulture. This "probe and learn" approach is highlighted by (Cole, 2002) as being a non-conventional approach to continuous improvement that is better suited to dynamic but uncertain business environments. The case points out that proven practices diffuse rapidly among the growers, which echoes a statement by (Miemczyk, 2008) who states that practice imitation occurs within industry groups to maintain legitimacy by imitating successful strategies and to minimize the risk of being a first mover in the market. It is stated by (Tey et al., 2014) that grower associations and cooperatives are particularly influential in this respect.

"The guidance provided by the cooperative serves mainly to align the strategic objectives of the growers. It is largely up to the growers how they integrate those objectives into their operations. The cooperative supports this process of operational integration by benchmarking grower performance over time, and by providing guidance for training."

The strategic prioritization of the organization refers to the degree of priority given to various strategic elements employed with the purpose of realizing a certain objective (Thoumy & Vachon, 2012). It is stated be (Yiu, Belayutham, & Gonz, 2016) that the functional focus of lean and environmental projects can impact the results that are achieved. It was demonstrated by (Thoumy & Vachon, 2012) that lean projects related to the main product, or underlying production process (as opposed to peripheral projects) can be financially more beneficial despite their disruptive nature and also that projects involving changes in the management systems are more profitable than the ones that entail a structural transformation.

5.2 Knowledge

The literature highlights the importance of knowledge in driving sustainable performance. The categories of knowledge identified as being important are several and include (i) knowledge pertaining to the nature of environmental and sustainability issues, (ii) knowledge pertaining to innovations and practices that would allow for improvements in sustainable performance, (iii) knowledge of the context in which the organization operates and (iv) knowledge related to perceptions of value by the various stakeholders within the organization itself, between elements of the supply chain and value as it is perceived by the customers. The case makes a clear connection to the importance of elements (i) and (ii), highlighting that growers are faced with a myriad of options when deciding how best to the pursue their performance objectives. This difficulty is corroborated by (Govindan et al., 2015) who states that growers may face challenges when integrating solutions from so many different backgrounds. The case posits that the growers and the cooperative have a very sound understanding of both environmental and social sustainability as it pertains to the agricultural sector, as technical divisions work aggregate the environmentally sustainable and socially ethical production standards for a range of markets, providing growers with a comprehensive set of minimum performance standards to implement. This is important, as the literature posits that a selective and disconnected examination of sustainable manufacturing practices denies stakeholders an overall understanding of sustainability initiatives (Wang, Subramanian, Gunasekaran, Abdulrahman, & Liu, 2015). In this respect the case recognizes the important role of specialist skills, both internal and external to the organization, in driving innovation and lean sustainability in grower operations. Consequently, the literature recognizes that sustainability improvements often require a combination of more than one type of knowledge and that specialist staff play a critically important role in capacitating these kinds of initiatives (Rothenberg, 2003). With regards to point (iii) the case draws a clear connection between the depth of understanding that workers possess about the land they work on and the results that they can achieve in the orchard, in terms of orchard yield and quality and in terms of minimizing waste. Finally, in relation to point (iv) the case outlines that it is necessary to understand and manage the perceptions of various actors in the chain.

"Our customers regularly come out to see our growing operations. They want to be assured that they are involved with agribusinesses that will support their reputation. They want to see it first hand, and the matter is taken very seriously."

With regard to managing perceptions, the requirement for traceability is noted, a factor highlighted by respondents as being foundational to the legitimization of sustainability practices. Followingly (Goul & Corral, 2007) supports that it is the requirements for traceable, environmental, and ethical goods that are driving the increased focus on primary producers in the supply chain. Additionally, the case highlights the importance of understanding stakeholder perception both in terms of what defines good fruit quality and in terms of what qualifies as sustainable production. With regards to the former, the case outlines that fruit quality attributes are clearly specified for the growers, and the group works alongside its customers to keep track of changes in consumer preferences.

5.3 Workforce and Training

The positive relationship between training and lean performance is well documented (Chaplin et al., 2016; Herron & Braiden, 2006). The case highlights the important contribution of the groups workforce toward achieving consistently good fruit output; this is true both at the operational and at the managerial level. As is posited by (Rougoor, Trip, Huirne, & Renkema, 1998), the outputs of a farm are fundamentally related to the degree of efficacy with which the grower is able to manage the inputs to production. The cooperative and growers view their accumulated skills and experience as a valuable organizational asset and commit a considerable amount of resources toward updating and developing the pool of available skills. This corresponds with the position of (Wong & Wong, 2014) that a lean organization values its workers as important assets (Wong & Wong, 2014). Training and development activities are cited in the case as being central to implementing new practices and integrating new technologies. It is posited that these two activities are necessarily complementary and that new technology cannot substitute for good personnel, a strategic outlook that is cited by (Thoumy & Vachon, 2012) as being supportive of lean and sustainable performance. The day to day activities of a growing operation take place over a relatively large geographical area; consequently, senior staff rely on their supervisors and team foremen to act as their eyes and ears in the orchards. The case posits that sufficient capacitation of key staff is necessary to ensure that workers are able to act independently and competently, a factor listed by (Rao, 2004) and (Rothenberg, 2003) as being an important enabler in a lean sustainable organizations. In this respect, the literature iterates that such individuals require a combination of both soft and hard skills to be effective team leaders (Dora et al., 2015). The case states that team foremen act as the link between management and workers, and that effective communication along this channel is essential to assure that operational plans are implemented properly. However, the case also states that the low level of literacy among workers acts as a barrier to proper training and development.

"Many of the laborers that work for us have not finished school, and even for those that have a matric, the quality of their education is often not worth much. This poses a challenge when we want to improve the skills of our workers, and then also it becomes difficult to develop a culture of learning."

Respondents highlight that, for those workers who are able and motivated, and who believe they can build a career in the industry, the efforts of training and development activities go a long way toward building long term motivation and commitment to their work, a point supported by (Vinodh, Ben Ruben, & Asokan, 2016). Additionally, it is pointed out that the cooperative has embarked on several social initiatives to build moral and provide additional social support for their workers, including providing on-site medical services, provision of child care and schooling facilities as well as morale building events for farm workers, stating that such efforts have a positive effect on workplace morale, discipline and absenteeism.

5.4 Operating Context

The literature has demonstrated that although lean methods are applicable in a wide range of industries and contexts (Holweg, 2007), the performance outcomes of operational management practices are impacted by the context in which they are implemented and thus need to be adapted to this new context in order to achieve the desired results (Sousa & Voss, 2001). The case posits that the context in which the growers operate is both highly dynamic, and highly complex; additionally, the case contends that elements of the context are becoming increasingly complex and dynamic over time, aligning with the supposition of (Azadegan, Patel, Zangoueinezhad, & Linderman, 2013) that manufacturers operate in ever more complex and volatile environments. Complexities arise firstly in terms of the increasingly high number and variety of actors in the fresh food supply chain, and secondly in terms of the increasingly accurate resolution with which growers are approaching their grower operations. Given the high number and variety of actors involved along the fresh fruit supply chain, and their various interrelationships, the situation resembles what (Cabral et al., 2012) describes as "complex networks with feedback and interdependence relationships between and amongst their actors.". Environmental dynamism arises through drivers of volatility and include factors such as weather and climate variability, evolving consumer preferences, economic (i.e. currency value) volatility and changes in regulatory context (Azadegan et al., 2013). A dynamic environment may act to distort the implementation of some lean practices; (Büyüközkan et al., 2015) states that where demand variability and product customization are high, inventory levels and frequency of delivery might increase, negatively impacting on business performance. However, an interesting point raised in the case states that the increased complexity of the operational context, particularly in terms of the broad customer portfolio and broad producer base, assists in mitigating a degree of risk associated such a dynamic context.

"Only six or seven years ago we were exporting to sixty-four countries, now we are exporting to slightly more than one hundred countries. Yes, this can be complex, but it is also beneficial for us. Having this diverse portfolio of clients helps us to mitigate some of the risk to sales management. Some clients might order less than planned for, whilst others may order more, the diversity of the portfolio helps to balance things out in the end."

Operating within the context of a developing country has several implications for the operating parameters of the growers and the cooperative. It is pointed out by (Karmarkar & Apte, 2007) that the evolution from an agricultural base towards a manufacturing and services base for some developed economies is mostly complete, a position that is not entirely congruent to the South African context outlined in the case, where the reality is structurally approximates the description by (Dethier & Effenberger, 2011) who states that some developing economies may be described as dual economies possessing both a traditional agricultural sector and a modern capitalist sector. This duality is detailed in the case, stating that growers benefit from access to world standard financial and legal systems to support the sector, but that these same growers face significant impediments on the side of labor supply and in terms of public sector institutional support for agricultural operations. The developing South African context, faces resource constraints in several respects, a point highlighted by (Shabeena Begam, Swamynathan, & Sekkizhar, 2013) and (Chaplin et al., 2016) as being a key consideration when adapting lean approaches to this context.

5.5 Organizational Structure

Both hard (e.g. size, layout, resources availability) and soft (e.g. developed suppliers/customers, organizational culture) facets of the organizational structure may act as determinants in an organizations ability to implement and sustain lean performance within and between organizations in the fresh fruit supply chain (Longoni, Pagell, Johnston, & Veltri, 2013; Verrier, Rose, & Caillaud, 2015; Wu et al., 2013). The case acknowledges the relationship between the size of a grower operation and the ability of that operation to adopt and integrate new innovations and technologies, stating that larger operations benefit from economies of scale and possess greater resources to commit toward implementing new innovations. The cooperative itself represents an additional hard element acting as an enabling factor for lean sustainable performance, as (Taylor, 2006) quotes the Curry Commission Report (Curry, 2002) outlining that "Primary producers, as well as collaborating vertically in the supply chain, should pool resources and collaborate horizontally to improve their marketing scope, and to enable them to negotiate with the much larger companies to which the sell to, and from which they buy.".

It is highlighted in the case that future trends in grower operations point toward the densification of orchards through the use of narrower orchard lanes, but that due to the 20 to 25 - year lifespan of apple and pear orchards, these changes would need to be phased in over a period of time. Additionally, it is pointed out that fundamental changes to the structure of the orchard could potentially offer performance benefits on several fronts including improved yield and quality of fruit, improved fuel efficiency and reduced carbon emissions using smaller more efficient tractors and reduced stress to orchard workers in the smaller and more accessible trees in the orchard lanes. The assertion made by the growers is affirmed by the studies of (Wu et al., 2013) and (Lapinski et al., 2006) which demonstrate that lean sustainable performance may be improved through improvement to the lay-out of the operating area. In this respect Grower B highlights success in the use of satellite loading facilities to reduce time, distance and consequently fruit damage between harvest and storage. Followingly, (Longoni et al., 2014) states that organizational structures can and should be designed to develop capabilities and mindsets to effectively achieve lean sustainable performance.

A great deal of exposition is provided regarding the forward integrated supply chain and its role in driving lean sustainable performance. It has been demonstrated by (Azadegan et al., 2013) that environmental complexity positively moderates the effects of lean operations and that environmental dynamism reduces the benefits of lean operations on performance. A dynamic environment necessitates greater agility in the supply chain, leading to a hybrid system that must by necessity possess the qualities of both a lean and agile system. The case details that the functional agility required in the chain is primarily assigned to elements downstream of the farm gate. The packhouse with its storage facilities represent what (Cox & Chicksand, 2005) term a functional decoupling point in a supply chain that requires a lean approach on the one point and a more agile approach at the other.

5.6 Technology and Decision Support

The case posits that with the presence of information technology, mechanization, science to account for the biophysical factors and other emerging technologies, the horticultural subsector is faced with a wide range of technological options to drive sustainable productivity growth. The case highlights the central role that technological innovation has in driving sustainable intensification in horticultural primary production, a position that corresponds with the writing of (Ioppolo et al., 2014) stating that the 3 dimensions of sustainability should be extended by a fourth – technological dimension. Although it is pointed out that technology plays a role in both small and large grower operations, the case posits that the size and availability of resources to a grower plays a very large role in supporting technology adoption, a position supported by (Thoumy & Vachon, 2012). The case highlighted that smaller grower operations rely on the cooperative's in house technical expertise to advise on innovation and technology options. In contrast, the case points out that grower D, the largest operation in the case, plays an active role in supporting innovative research efforts within the group, providing a testing ground for new innovations and approaches that might, in the future, be promoted to the groups as a whole. The case study demonstrates on several fronts that growers are facing an increasingly complex marketplace with an increasingly complex supply chain serving ever more exacting customer expectations. Followingly, they are becoming progressively more reliant on innovative, often technology based approaches (Chuang, 2014), to assist with operational planning and oversight (Cabral et al., 2012). Between the growers, three levels of decision support systems are identified, firstly for production planning and crop programming, secondly at the level of harvest quality control and lastly at the level of orchard operational control. Interestingly, these 3 levels of decision support are active within each grower operation in the group, indicative of the cooperative's institutional role in promoting isomorphism between growers.

"If you go to the different growers, you will find that they employ similar mechanisms to control for quality. Even the guys in Elgin, you will find these same mechanisms there. There might be differences in how they implement those controls, but you will find that they all link up with the system at the pack house."

The highest level of decision support is evident in the crop programming process of aligning grower output with customer demands and specifications. Crop programming represents what (Goul & Corral, 2007) term processes and systems designed to coordinate multiple, disparate, and distributed organizational and inter-organizational decision points, contexts and resources to create value. The case iterates the importance of this process in maximizing revenue for the growers. During harvest periods growers utilized statistical sampling methods to assess the quality of their harvest, linking this sampling process to a near immediate feedback channel to operations back in the orchards. As stated by (Rothenberg, 2003) for lean processes to function properly, there must be adequate measurement and use of data related to important process outcomes. Quality control data, being universally comparable across grower operations, is utilized for benchmarking grower operations within the group, allowing for comparative assessment of grower methods, a factor that is highlighted as an important driver of lean sustainable performance (S. G. Azevedo et al., 2016). Interestingly, each of the growers highlighted that with the growing role of technology in the orchards has minimally changed their relationship with labor. Rather, the growers posit that the growing reliance on new technology and technical innovations motivate for ever-greater development of the workforce matched with effective managerial processes and procedures.

6. Conclusion

As the global economy confronts the growing demand for agricultural production in the context of increasingly limited productive capacity, the experts agree that the means of agricultural production needs to become more sustainable. Research in the field of operations management has demonstrated that lean management practices have the potential to drive sustainable organizational performance. This trend is now also evident in an emerging body of research demonstrating the potential for lean to drive sustainable performance in the agricultural sector. However, this area of research is still in its relatively early stages with only a handful of papers touching upon the subject of lean in agricultural primary production. This paper makes a significant inroad into this field, firstly by systematically identifying determinants of lean driven sustainable performance in the literature and secondly through the development of a case study providing functional exposition of those determinants within the operations of four apple and pear primary producers as they operate and collaborate within the context of an agricultural cooperative. The overarching narrative, in terms of the case analysis and discussion, provides detailed insight into the configuration of grower practices, the manner in which they are adapted to suit the fresh fruit primary production context and the extent to which they enable a lean operating environment. In this respect several unique characteristics of this context are recognized and examined.

The two distinguishing characteristics of the primary production environment are firstly, the extraordinary biophysical and climatic dynamism of the operating environment, and secondly, the seasonal batch process inherent in the cultivation of fruit. Although downstream elements of the fresh food supply chain also have to contend with perishability of produce, they are largely isolated from the climatic and biophysical risks associated with production. Additionally, seasonal batch production distinguishes this context from that of services or manufacturing environments, where services may be provided, or products may be manufactured, in discrete increments, and in direct response to a specific customer order or signal for production. Whilst biophysical and climatic dynamism are unavoidable endogenous sources of risk with which the grower has to contend, seasonal batch production has the functional effect of exposing grower operations to a significant source of exogenous risk, that of dynamism associated with the market demand for their produce. Together these elements of endogenous and exogenous dynamism impose themselves as barriers to the establishment of pull production and flow, the two elements identified as the cornerstones of a lean system of production. This reinforces the findings of previous studies, that lean systems in agriculture may face impediments in the form of organizational and chain instability.

Evidently the structural elements of the group, the growers, cold chain and sales and marketing, are strategically configured to mitigate this instability. The integration of cold storage capabilities into the chain is the initial step toward breaking the rigidity of seasonal batch production, decoupling the supply of produce from the dictates of the harvest. This functional agility afforded by the cold chain is harmoniously matched with a process of forward contracting by which the cooperative is able to confirm a set of customer orders up to a year in advance. It is the combination of these two elements that enables primary producers to plan beyond the 1-year seasonal horizon and set production targets relative to determined customer expectations, thus functionally transforming the system of production into one that closely approximates a pull system. Nevertheless, the findings highlight the shortcomings of this approximation. The contracting system incorporates a degree of contractual flexibility through which customers might make adjustments to order volumes, exposing the group to a residual demand side risk. This risk is largely mitigated through the diversification of demand across a broad buyer portfolio; reduced order volumes in some markets may be off-set by increased order volumes in others. However, the group also faces uncertainty with regard to production volumes, a functional result of the inherent climatic and biophysical dynamics within the production environment.

The confluence of demand and supply side dynamics generate an uneasy zero-sum balance between risks of underproduction and overproduction. Customer orientation is clearly reflected in the groups significant emphasis on avoiding underproduction; placing a premium on their ability to reliably meet customer orders. Followingly the risk of underproduction is mitigated in two respects. Firstly, the relatively large number of growers that comprise the group and the distribution of their farms between two geographically distinct growing regions serves to mitigate a degree of dynamism with regard to the climatic and biophysical elements of production. Secondly, and arguably more significantly, is the strategic position assumed by the group, taking a very conservative approach to production planning, which largely mitigates any risk of underproduction, but which correspondingly transforms this risk into degrees of overproduction. Nevertheless, any resulting surpluses in production may simply be stored and "pushed" through available sales channels at an opportune time. This adherence to reliability aligns strongly with the prevailing lean literature and is a trait which garners a premium within the inherently dynamic fresh food setting, supporting robustness in the buyer-supplier relationship. This strategic organizational configuration serves to align productive capacity of the group with the demand characteristics of the market, whilst functionally mitigating contextual dynamism and maximizing customer value. This study supports the established position that the performance benefits of lean systems correlate directly with contextual complexity but inversely with contextual dynamism. Interestingly, the case demonstrates a configuration in which elements of complexity are used as a diversification factor to mitigate against contextual dynamism. Moreover, the chain is structured so as to position the point of aggregation and storage as being a decoupling point between the lean focused grower operations and the lean-agile paradigm necessitated downstream in the chain.

Grower operations guided by and aligned to the functions of the forward integrated chain are thus the enabling factor for the attainment of lean driven sustainable performance at the primary production level. With sources of demand side dynamism largely addressed, the growers are liberated to direct their efforts toward driving and refining their internal practices. In line with the prevailing literature presented evidence confirms the positive relationship between the size of the grower operation, the capacitation of the workforce and the ability of the operation to attain superior sustainable performance outcomes. In this respect, it is pointed out that the sharing of capacities between members of the group may help overcome some of the resource limitations of the smaller growers. Likewise, the growing role of technology in driving sustainable performance is confirmed; firstly, through bioscientific innovations driving improvements in yield and quality of produce and secondly in terms utilizing digital and remote sensing technologies to manage the complexity of grower operations. The connections between technology and operational management are made evident by the adherence to data-based decision controls, at the level of the individual grower, in terms of orchard management and harvest process control, as well as at the group level, serving the needs of crop programming and practice benchmarking processes. Notably, the findings allude to the fact that this growing role of technology acts less as a substitute and more as a driver for the adoption of lean methods, where arguably the budding role of innovation in maintaining competitive advantage necessitates an attitude of continuous improvement, promoting the importance of procedures and work habits that enable such a culture. Lastly, the groups "probe and adopt" approach to practice innovation represents a functionally strategic posture adopted in response to the highly dynamic nature of the primary production environment. Whilst the literature supports that this approach is suited to dynamic contexts, the case alludes to the comparatively lengthy timelines and relative inflexibility inherent in orchard development as being a contributing factor toward this end. Nevertheless, the strategic intent of this approach is congruent with a range of other structural and strategic configurations, previously outlined, intending to isolate and mitigate against contextual dynamism; demonstrating a functionally consistent configuration for the group as a whole.

6.1 Limitations and Future Research Directions

There are several limitations of this research with respect to comparability and generalizability that require comment. The analysis presented in this study is specifically focused on primary producers operating in the context of an agricultural cooperative integrated with downstream elements of the chain. The findings indicate that the employed lean strategies are shaped significantly by linkages to those downstream elements and thus these findings may not be generalizable to primary producers who are not positioned within a functionally comparable organizational structure. Additionally, this study was based upon personal accounts offered by key industry stakeholders, and therefore possible knowledge limitations or biases must be acknowledged. Nevertheless, these limitations also serve to highlight potential avenues for future research. Considering the relatively specific focus of this case, it would be of interest to consider primary producers confronted with different operational contexts, particularly those confronted by varying degrees of horizontal, forward (i.e. vertical) or technological integration.

Several stakeholders interviewed over the course of this study highlighted that the usefulness of this research would be enhanced by considering less "well-resourced" segments of the fruit horticultural subsector, whether through additional case studies or through the empirical assessment of data across a larger more representative sample of growers. Further studies could also provide more detailed exposition on the attainable performance outcomes or consider agricultural readiness factors for the adoption of lean practices. In this regard the analytical framework presented in this study could serve as a useful point of departure. Nevertheless, the in-depth case discussion and analysis detailed in this study represent a new contribution to the body of lean research. This contribution will hopefully support practitioners and researchers as they further the development of lean management practices and approaches in the horticultural subsector.

7. References

Aguado, S., Alvarez, R., & Domingo, R. (2013). Model of ef fi cient and sustainable improvements in a lean production system through processes of environmental innovation. *Journal of Cleaner Production*, *47*, 141–148. http://doi.org/10.1016/j.jclepro.2012.11.048

Ahmad, S., & Schroeder, R. G. (2003). The impact of human resource management practices on operational performance recognizing country and industry differences. *Journal of Operations Management*, *21*(1), 19.

Archer, a. A., Higgins, A. J., & Thorburn, P. J. (2009). A method for comprehending and adapting complex supply chains in agriculture. *Journal on Chain and Network Science*, *9*(1), 9–15. http://doi.org/10.3920/JCNS2009.x136

Azadegan, A., Patel, P. C., Zangoueinezhad, A., & Linderman, K. (2013). The effect of environmental complexity and environmental dynamism on lean practices. *Journal of Operations Management*, *31*(4), 193–212. http://doi.org/10.1016/j.jom.2013.03.002

Azevedo, S. G., Carvalho, H., & Cruz-Machado, V. (2016). LARG index: A benchmarking tool for improving the leanness, agility, resilience. *Benchmarking: An International Journal*, *23*(6), 1472–1499. http://doi.org/10.1108/BIJ-07-2014-0072

Azevedo, S. G., Carvalho, H., Duarte, S., & Cruz-Machado, V. (2012). Influence of Green and Lean Upstream Supply Chain Management Practices on Business Sustainability. *IEEE Transactions on Engineering Management*, *59*(4), 753–765. http://doi.org/10.1109/TEM.2012.2189108

Becker, H. S. (1970). *Sociological Work: Method and Science*. Chicago: Aldine.

Bergenwall, A. L., Chen, C., & White, R. E. (2012). TPSs process design in American automotive plants and its effects on the triple bottom line and sustainability. *International Journal of Production Economics*, *140*(1), 374–384. http://doi.org/10.1016/j.ijpe.2012.04.016

Bergmiller, G. G., & Mccright, P. R. (2009). Parallel Models for Lean and Green Operations. *Industrial Engineering Research Conference*, 1138–1143.

BFAP. (2016). *BFAP Baseline: Agricultural Outlook 2016-2025*. Pretoria. Retrieved from http://www.bfap.co.za/index.php/baselines

Bortolotti, T., Romano, P., Martínez-Jurado, P. J., & Moyano-Fuentes, J. (2016). Towards a theory for lean implementation in supply networks. *International Journal of Production Economics*, *175*, 182–196. http://doi.org/10.1016/j.ijpe.2016.02.020

Büyüközkan, G., Kayakutlu, G., & Karakadılar, İ. S. (2015). Assessment of Lean Manufacturing Effect on Business Performance using Bayesian Belief Networks. *Expert Systems with Applications*, *42*(19), 6539–6551. http://doi.org/10.1016/j.eswa.2015.04.016

Cabral, I., Grilo, A., & Cruz-Machado, V. (2012). A Decision-Making Model for Lean, Agile, Resilient and Green Supply Chain Management. *International Journal of Production Research*, *50*(17), 4830–4845.

http://doi.org/10.1080/00207543.2012.657970

Carter, C. R., & Rogers, D. S. (2008). A framework of sustainable supply chain management: moving toward new theory. *International Journal of Physical Distribution & Logistics Management*, *38*(5), 360–387. http://doi.org/10.1108/09600030810882816

Chaplin, L., Heap, J., & O'Rourke, S. T. J. (2016). Could "Lean Lite" be the cost effective solution to applying lean manufacturing in developing economies? *International Journal of Productivity and Performance Management*, *66*(1), 126–136. http://doi.org/10.1108/IJPPM-02-2015-0034

Cherrafi, A., Elfezazi, S., Chiarini, A., Mokhlis, A., & Benhida, K. (2016a). The integration of lean manufacturing, Six Sigma and sustainability: A literature review and future research directions for developing a specific model. *Journal of Cleaner Production*, *139*, 828–846. http://doi.org/10.1016/j.jclepro.2016.08.101

Cherrafi, A., Elfezazi, S., Chiarini, A., Mokhlis, A., & Benhida, K. (2016b). The integration of lean manufacturing, Six Sigma and sustainability: A literature review and future research directions for developing a specific model. *Journal of Cleaner Production*, *139*, 828–846. http://doi.org/10.1016/j.jclepro.2016.08.101

Chiarini, A. (2015). Environmental Policies for Evaluating Suppliers' Performance Based on GRI Indicators. *Business Strategy and the Environment*, *26*(1), 98–111. http://doi.org/10.1002/bse.1907

Chikudate, N. (2009). Collective hyperopia and dualistic natures of corporate social responsibility in Japanese companies. *Asian Business & Management*, *8*(2), 169–184. http://doi.org/10.1057/abm.2009.4

Child, J. (1972). Organizational structure, environment and performance: The role of strategic choice, (May), 1–22. http://doi.org/10.1177/003803857200600101

Chuang, S. P. (2014). Assessing and improving the green performance using a compound approach. *Flexible Services and Manufacturing Journal*, *26*(1–2), 69–91. http://doi.org/10.1007/s10696-012-9156-1

Cole, R. E. (2002). From continuous improvement to continuous innovation. *Total Quality Management*, *13*(8), 1051–1056. http://doi.org/10.1080/09544120200000001

Colgan, C., Adam, G., & Topolansky, F. (2013). Why try Lean? A Northumbrian Farm case study. Retrieved April 11, 2016, from http://ageconsearch.umn.edu/bitstream/175041/2/170_Colgan.pdf

Cox, A., & Chicksand, D. (2005). The Limits of Lean Management Thinking: *European Management Journal*, *23*(6), 648–662. http://doi.org/10.1016/j.emj.2005.10.010

Cox, A., Chicksand, D., & Palmer, M. (2007). Stairways to heaven or treadmills to oblivion? *British Food Journal*, *109*(9), 689–720. http://doi.org/10.1108/00070700710780689

Curry, D. (2002). FARMING & FOOD a sustainable future. *Report of the Policy Commission on the Future of Farming and Food*, january.

Dakov, I., & Novkov, S. (2007). Assessment of the Lean Production Effect on the Sustainable Industrial Enterprise. *Business: Theory and Practice*, *8*(4), 183–188.

Davis, K. F., Gephart, J. A., Emery, K. A., Leach, A. M., Galloway, J. N., & D'Odorico, P. (2016). Meeting future food demand with current agricultural resources. *Global Environmental Change*, *39*, 125–132. http://doi.org/10.1016/j.gloenvcha.2016.05.004

Dethier, J.-J., & Effenberger, A. (2011). Agriculture and development: A brief review of the literature. *Economic Systems*, *36*(2), 175–205. http://doi.org/10.1016/j.ecosys.2011.09.003

Dhingra, R., Kress, R., & Upreti, G. (2014). Does lean mean green? *Journal of Cleaner Production*, *85*, 1–7. http://doi.org/10.1016/j.jclepro.2014.10.032

Diesling, P. (1971). *Patterns of Discovery in the Social Sciences*. Chicago: Transaction Publishers.

DiMaggio, P. J., & Powell, W. W. (1983). The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields. *American Sociological Review*, *48*(2), 147–160.

Dora, M., Kumar, M., & Gellynck, X. (2015). Determinants and barriers to lean implementation in food-processing SMEs – a multiple case analysis. *Production Planning & Control*, *27*(1), 1–23. http://doi.org/10.1080/09537287.2015.1050477

Dutt, N., & King, A. A. (2014). The Judgement of Garbage: End-of-Pipe Treatment and Waste Reduction. *Management Science*, *60*(7), 1812–1828.

Eisenhardt, K. M. (2016). Building Theories from Case Study Research. *Academy of Management*, *14*(4), 532–550. Retrieved from http://www.jstor.org/stable/258557 Linked references are

Faulkner, W., & Badurdeen, F. (2014). Sustainable Value Stream Mapping (Sus-VSM): Methodology to visualize and assess manufacturing sustainability performance. *Journal of Cleaner Production*, *85*, 8–18. http://doi.org/10.1016/j.jclepro.2014.05.042

Fliedner, G., & Majeske, K. (2010). Sustainability : The New Lean Frontier. *Production and Inventory Management Journal*, *46*(1), 6–13.

Foley, J. A., Ramankutty, N., Brauman, K. A., Cassidy, E. S., Gerber, J. S., Johnston, M., … Zaks, D. P. M. (2011). Solutions for a cultivated planet. *Nature*, *478*(7369), 337–342. Retrieved from http://dx.doi.org/10.1038/nature10452

Folinas, D., Aidonis, D., Triantafillou, D., & Malindretos, G. (2013). Exploring the Greening of the Food Supply Chain with Lean Thinking Techniques. *Procedia Technology*, *8*, 416–424. http://doi.org/10.1016/j.protcy.2013.11.054

Fred-Koller, E. (1950). Vertical Integration of Agricultural Economics. *American Journal of Agricultural Economics*, *32*(4), 1048–1058. http://doi.org/https://doi.org/10.2307/1233856

Garza-Reyes, J. A. (2015). Lean and Green – A systematic review of the state of the art literature. *Journal of Cleaner Production*, *102*, 18–29. http://doi.org/10.1016/j.jclepro.2015.04.064

Ghauri, P. N., & Grønhaug, K. (2005). *Research methods in business studies : a practical guide*. Financial Times Prentice Hall. Retrieved from https://books.google.be/books/about/Research_Methods_in_Business_Studies.html?id=-sTUDbaefgkC&redir_esc=y

Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., … Toulmin, C. (2012). The Challenge of Food Security. *Science*, *327*(February), 812. http://doi.org/10.4337/9780857939388

Gordon, P. J. (2001). *Lean and green : profit for your workplace and the environment*. Berrett-Koehler Publishers.

Goul, M., & Corral, K. (2007). Enterprise model management and next generation decision support. *Decision Support Systems*, *43*(3), 915–932. http://doi.org/10.1016/j.dss.2005.05.023

Govindan, K., Azevedo, S. G., Carvalho, H., & Cruz-Machado, V. (2015). Lean, green and resilient practices influence on supply chain performance: interpretive structural modeling approach. *International Journal of Environmental Science and Technology*, *12*(1), 15–34. http://doi.org/10.1007/s13762-013-0409-7

Govindan, K., Jafarian, A., Khodaverdi, R., & Devika, K. (2014). Two-echelon multiple-vehicle location–routing problem with time windows for optimization of sustainable supply chain network of perishable food. *International Journal of Production Economics*, *152*, 9–28. http://doi.org/10.1016/j.ijpe.2013.12.028

Hajmohammad, S., Vachon, S., Klassen, R. D., & Gavronski, I. (2013). Lean management and supply management: their role in green practices and performance. *Journal of Cleaner Production*, *39*, 312–320. http://doi.org/10.1016/j.jclepro.2012.07.028

Hallgren, M., & Olhager, J. (2009). Lean and agile manufacturing: external and internal drivers and performance outcomes. *International Journal of Operations & Production Management*, *29*(10), 976–999. http://doi.org/10.1108/01443570910993456

Herron, C., & Braiden, P. M. (2006). A methodology for developing sustainable quantifiable productivity improvement in manufacturing companies. *International Journal of Production Economics*, *104*(1), 143–153. http://doi.org/10.1016/j.ijpe.2005.10.004

Holweg, M. (2007). The genealogy of lean production. *Journal of Operations Management*, *25*(2), 420–437. http://doi.org/10.1016/j.jom.2006.04.001

Hortgro. (2016). *Key Deciduous Fruit Statistics*. Cape Town. Retrieved from https://www.hortgro.co.za/wp-content/uploads/2017/08/key-deciduous-fruit-statistics-2016.pdf

Ioppolo, G., Cucurachi, S., Salomone, R., Saija, G., Ciraolo, L., Ioppolo, G., … Ciraolo, L. (2014). Industrial Ecology and Environmental Lean Management: Lights and Shadows. *Sustainability*, *6*(9).

Jarebrant, C., Winkel, J., Hanse, J. J., Mathiassen, S. E., & Ojmertz, B. (2016). ErgoVSM: A Tool for Integrating Value Stream Mapping and Ergonomics in Manufacturing. *Human Factors and Ergonomics in Manufacturing*, *16*(1), 61–81. http://doi.org/10.1002/hfm

Jeffers, P. I. (2010). *Embracing sustainability*. *International Journal of Operations & Production Management* (Vol. 30). http://doi.org/http://dx.doi.org/10.1108/01443571011024629

Karmarkar, U. S., & Apte, U. M. (2007). Operations management in the information economy: Information products, processes, and chains. *Journal of Operations Management*, *25*(2), 438–453. http://doi.org/10.1016/j.jom.2006.11.001

Koranda, C., Chong, W. K., Kim, C., Chou, J. S., & Kim, C. (2012). An investigation of the applicability of sustainability and lean concepts to small construction projects. *KSCE Journal of Civil Engineering*, *16*(5), 699–707. http://doi.org/10.1007/s12205-012-1460-5

Lapinski, A. R., Horman, M. J., & Riley, D. R. (2006). Lean Processes for Sustainable Project Delivery. *Journal of Construction Engineering and Management*, *132*(10), 1083–1091. http://doi.org/10.1061/(ASCE)0733-9364(2006)132:10(1083)

Lewis, M. A. (2000). Lean production and sustainable competitive advantage. *International Journal of Operations & Production Management2*, *20*(8), 959–978.

Longoni, A., & Cagliano, R. (2015). Cross-functional executive involvement and worker involvement in lean manufacturing and sustainability alignment. *International Journal of Operations & Production Management*, *35*(9), 1332–1358. http://doi.org/10.1108/IJOPM-02-2015-0113

Longoni, A., Golini, R., & Cagliano, R. (2014). The role of New Forms of Work Organization in developing sustainability strategies in operations. *International Journal of Production Economics*, *147*(PART A), 147–160. http://doi.org/10.1016/j.ijpe.2013.09.009

Longoni, A., Pagell, M., Johnston, D., & Veltri, A. (2013). When does lean hurt? – an exploration of lean practices and worker health and safety outcomes. *International Journal of Production Research*, *51*(11), 3300–3320. http://doi.org/10.1080/00207543.2013.765072

Lötze, E., & Bergh, O. (2004). Early prediction of harvest fruit size distribution of an apple and pear cultivar. *Scientia Horticulturae*, *101*(3), 281–290. http://doi.org/10.1016/j.scienta.2003.11.006

Louhichi, K., Alary, V., & Grimaud, P. (2004). A dynamic model to analyse the bio-technical and socio-economic interactions in dairy farming systems on the Reunion Island. *Animal Research*, *53*(5), 363–382. Retrieved from https://hal.archives-ouvertes.fr/hal-00889937/document

Martínez-Jurado, P. J., & Moyano-Fuentes, J. (2013). Lean Management, Supply Chain Management and Sustainability: A Literature Review. *Journal of Cleaner Production*, *85*, 134–150. http://doi.org/10.1016/j.jclepro.2013.09.042

McCown, R. L. (2002). Locating agricultural decision support systems in the troubled past and socio-technical complexity of 'models for management.' *Agricultural Systems*, *74*(1), 11–25. http://doi.org/10.1016/S0308-521X(02)00020-3

Miemczyk, J. (2008). An exploration of institutional constraints on developing end-of-life product recovery capabilities. *International Journal of Production Economics*, *115*(2), 272–282. http://doi.org/10.1016/j.ijpe.2008.04.013

Muller-Merbach, H. (2010). The OR/MS process: An orphan? The five sections analysis. *Omega*. http://doi.org/10.1016/j.omega.2009.10.004

Nagalingam, S. V., Kuik, S. S., & Amer, Y. (2013). Performance measurement of product returns with recovery for sustainable manufacturing. *Robotics and Computer-Integrated Manufacturing*, *29*(6), 473–483. http://doi.org/10.1016/j.rcim.2013.05.005

Nuthall, P. (2009). Modelling the origins of managerial ability in agricultural production. *Australian Journal of Agricultural and Resource Economics*, *53*(3), 413–436. http://doi.org/10.1111/j.1467-8489.2009.00459.x

Pagell, M., Dibrell, C., Veltri, A., & Maxwell, E. (2014). Is an efficacious operation a safe operation: The role of operational practices in worker safety outcomes. *IEEE Transactions on Engineering Management*, *61*(3), 511–521. http://doi.org/10.1109/TEM.2014.2316249

Pampanelli, A. B., Found, P., & Bernardes, A. M. (2014). A Lean & Green Model for a production cell. *Journal of Cleaner Production*, *85*, 19–30. http://doi.org/10.1016/j.jclepro.2013.06.014

Piercy, N., & Rich, N. (2015). The relationship between lean operations and sustainable operations. *International Journal of Operations & Production Management*, *35*(2), 282–315. http://doi.org/10.1108/IJOPM-03-2014-0143

Pla, L. M., Sandars, D. L., & Higgins, A. J. (2014). A perspective on operational research prospects for agriculture. *Journal of the Operational Research Society*, *65*(7), 1078–1089. http://doi.org/10.1057/jors.2013.45

Power, A. G. (2010). Ecosystem services and agriculture: tradeoffs and synergies. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *365*(1554), 2959–2971. http://doi.org/10.1098/rstb.2010.0143

Rao, P. (2004). Greening production: a South-East Asian experience. *International Journal of Operations & Production Management*, *24*(3), 289–320. http://doi.org/10.1108/01443570410519042

Rosenbaum, S., Toledo, M., & González, V. (2014). Improving Environmental and Production Performance in Construction Projects Using Value-Stream Mapping: Case Study. *Journal of Construction Engineering and Management*, *140*(2), 04013045. http://doi.org/10.1061/(ASCE)CO.1943-7862.0000793

Rothenberg, S. (2003). Knowledge Content and Worker Participation in Environmental Management at NUMMI. *Journal of Management Studies*, *40*(7), 1783–1802. http://doi.org/10.1111/1467-6486.00400

Rothenberg, S., Pil, F. K., & Maxwell, J. (2009). Lean, Green, and the Quest for Superior Environmental Performance. *Production and Operations Management*, *10*(3), 228–243. http://doi.org/10.1111/j.1937-5956.2001.tb00372.x

Rougoor, C. W., Trip, G., Huirne, R. B. m, & Renkema, J. A. (1998). How to define and study farmers' management capacity: Theory and use in agricultural economics. *Agricultural Economics*, *18*(3), 261–272. http://doi.org/10.1016/S0169-5150(98)00021-8

Sagnak, M., & Kazancoglu, Y. (2015). Integration of green lean approach with six sigma: An application for flue gas emissions. *Journal of Cleaner Production*, *127*, 112–118. http://doi.org/10.1016/j.jclepro.2016.04.016

Saunders, P. A., Tractenberg, R. E., Chaterji, R., Amri, H., Harazduk, N., Gordon, J. S., … Haramati, A. (2007). Promoting self-awareness and reflection through an experiential Mind-Body Skills course for first year medical students. *Medical Teacher*, *29*(8), 778–784. http://doi.org/10.1080/01421590701509647

Sekar, V., Vinoth, C., & Sundaram, S. (2015). Journal of Manufacturing Technology Management Assessment of fitness of a manufacturing organization using fuzzy methods Assessment of fitness of a manufacturing organization using fuzzy methods. *Journal of Manufacturing Technology Management Journal of Manufacturing Technology Management Iss Journal of Manufacturing Technology Management Iss Journal of Manufacturing Technology Management*, *26*(4), 561–581. http://doi.org/10.1108/JMTM-09-2012-0078

Shabeena Begam, M., Swamynathan, R., & Sekkizhar, J. (2013). Current trends on lean management – a review. *International Journal of Lean Thinking*, *4*(2), 89–96.

Shah, R., & Ward, P. (2003). Lean manufacturing: context, practice bundles, and performance. *Journal of Operations Management*, *21*(2), 129–149. http://doi.org/10.1016/S0272-6963(02)00108-0

Shah, R., & Ward, P. (2007). Defining and developing measures of lean production. *Journal of Operations Management*, *25*(4), 785–805. http://doi.org/10.1016/j.jom.2007.01.019

Simons, D., & Taylor, D. (2007). Lean thinking in the UK red meat industry : A systems and contingency approach, *106*, 70–81. http://doi.org/10.1016/j.ijpe.2006.04.003

Simons, D., & Zokaei, K. (2005). Application of lean paradigm in red meat processing. *British*, *107*(4), 192–211. http://doi.org/10.1108/00070700510589495

Sivakumar, D., Jiang, Y., & Yahia, E. M. (2011). Maintaining mango (Mangifera indica L.) fruit quality during the export chain. *Food Research International*, *44*(5), 1254–1263. http://doi.org/10.1016/j.foodres.2010.11.022

Sousa, R., & Voss, C. A. (2008). Contingency research in operations management practices. *Journal of Operations Management*, *26*(6), 697–713. http://doi.org/10.1016/j.jom.2008.06.001

Sousa, R., & Voss, C. a. (2001). Quality Management: Universal or Context Dependent? *Production and Operations Management*, *10*(4), 383–404. http://doi.org/10.1111/j.1937-5956.2001.tb00083.x

Stanley, C. J., Tustin, D. S., Lupton, G. B., Mcartney, S., Cashmore, W. M., & Silva, H. N. De. (2000). Towards understanding the role of temperature in apple fruit growth responses in three geographical regions within New Zealand. *The Journal of Horticultural Science and Biotechnology*, *75*(4), 413–422. http://doi.org/10.1080/14620316.2000.11511261

Taubitz, M. A. (2010). Lean, Green &Safe: Integrating Safety into the Lean, Green and Sustainability Movement. *Professional Safety*, *55*(05), 39–46. Retrieved from https://www.onepetro.org/journal-paper/ASSE-10-05-39

Taylor, D. H. (2006). Strategic considerations in the development of lean agri-food supply chains: a case study of the UK pork sector. *Supply Chain Management-An International Journal*, *11*(3), 271–280.

Tey, Y. S., Li, E., Bruwer, J., Abdullah, A. M., Brindal, M., Radam, A., … Darham, S. (2014). The relative importance of factors influencing the adoption of sustainable agricultural practices: a factor approach for Malaysian vegetable farmers. *Sustainability Science*, *9*(1), 17–29. http://doi.org/10.1007/s11625-013-0219-3

Thomas, J., Harden, A., Thomas,James, & Harden,Angela. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Medical Research Methodology*, *8*(1), 45. http://doi.org/10.1186/1471-2288-8-45

Thoumy, M., & Vachon, S. (2012). Environmental projects and financial performance: Exploring the impact of project characteristics. *International Journal of Production Economics*, *140*(1), 28–34.

http://doi.org/10.1016/j.ijpe.2012.01.014

Vachon, S., & Klassen, R. D. (2006). *Extending green practices across the supply chain: The impact of upstream and downstream integration*. *International Journal of Operations & Production Management* (Vol. 26). http://doi.org/10.1108/01443570610672248

Verrier, B., Rose, B., & Caillaud, E. (2015). Lean and Green strategy: The Lean and Green House and maturity deployment model. *Journal of Cleaner Production*, *116*, 150–156. http://doi.org/10.1016/j.jclepro.2015.12.022

Verrier, B., Rose, B., Caillaud, E., & Remita, H. (2014). Combining organizational performance with sustainable development issues: the Lean and Green project benchmarking repository. *Journal of Cleaner Production*, *85*, 83–93. http://doi.org/10.1016/j.jclepro.2013.12.023

Vinodh, S., Arvind, K. R., & Somanaathan, M. (2011). Tools and techniques for enabling sustainability through lean initiatives. *Clean Technologies and Environmental Policy*, *13*(3), 469–479. http://doi.org/10.1007/s10098-010-0329-x

Vinodh, S., Ben Ruben, R., & Asokan, P. (2016). Life cycle assessment integrated value stream mapping framework to ensure sustainable manufacturing: A case study. *Clean Technologies and Environmental Policy*, *18*(1), 279–295. http://doi.org/10.1007/s10098-015-1016-8

Vinodh, S., Ramesh, K., & Arun, C. S. (2016). Application of interpretive structural modelling for analysing the factors influencing integrated lean sustainable system. *Clean Technologies and Environmental Policy*, *18*(2), 413–428. http://doi.org/10.1007/s10098-015-1025-7

Vitousek, P. M., Mooney, H. a, Lubchenco, J., & Melillo, J. M. (1997). Human Domination of Earth' s Ecosystems. *Science*, *277*(5325), 494–499. http://doi.org/10.1126/science.277.5325.494

Wang, C. N., Huang, Y. F., Le, T. N., & Ta, T. T. (2016). An innovative approach to enhancing the sustainable development of japanese automobile suppliers, *8*(5), 1–19. http://doi.org/10.3390/su8050420

Wang, Subramanian, N., Gunasekaran, A., Abdulrahman, M. D., & Liu, C. (2015). Composite sustainable manufacturing practice and performance framework: Chinese auto-parts suppliers' perspective. *International Journal of Production Economics*, *170*, 219–233. http://doi.org/10.1016/j.ijpe.2015.09.035

Wiese, A., Luke, R., Heyns, G. J., & Pisa, N. M. (2015). The integration of lean, green and best practice business principles. *Journal of Transport and Supply Chain Management*, *9*(1), 1–10. http://doi.org/10.4102/jtscm.v9i1.192

Wong, W. P., & Wong, K. Y. (2014). Synergizing an ecosphere of lean for sustainable operations. *Journal of Cleaner Production*, *85*, 51–66. http://doi.org/10.1016/j.jclepro.2014.05.093

Wu, P., Low, S. P., & Jin, X. (2013). Identification of non-value adding (NVA) activities in precast concrete installation sites to achieve low-carbon installation. *Resources, Conservation and Recycling*, *81*, 60–70. http://doi.org/10.1016/j.resconrec.2013.09.013

Yang, M. G., Hong, P., & Modi, S. B. (2011). Impact of lean manufacturing and environmental management on business performance: An empirical study of manufacturing firms. *International Journal of Production Economics*, *129*(2), 251–261. http://doi.org/10.1016/j.ijpe.2010.10.017

Yin, R. K. (2013). *Case Study Research: Design and Methods*. SAGE Publications. Retrieved from https://books.google.com/books?hl=en&lr=&id=OgyqBAAAQBAJ&pgis=1

Yiu, T. W., Belayutham, S., & Gonz, V. A. (2016). Clean - lean administrative processes : a case study on sediment pollution during construction, *126*, 134–147. http://doi.org/10.1016/j.jclepro.2016.02.091

Zokaei, K., & Simons, D. (2006). Performance Improvements through Implementation of Lean Practices : A Study of the U . K . Red Meat Industry, *9*(2), 30–53.