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Managing and measuring sustainability performance of supply chains

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ABSTRACT: Sustainable development from an industrial perspective has extended beyond organisational boundaries to incorporate a supply chain approach. This paper provides a framework which can assist focal companies in development of sustainable supply chains. The literature related to sustainable supply chain evaluation is reviewed incorporating concepts from four organisational theories including the resource based, institutional, stakeholder and social network perspectives to illustrate key drivers and enablers of sustainability initiatives in the supply chain. A conceptual multidimensional framework is then developed which can serve as a tool for research scholars and supply chain practitioners in identifying and assessing various economic, environmental and social performance indicators.

KEY WORDS: ***Sustainability Assessment, Supply Chain Sustainability Performance, Supply Chain Management, Multidimensional Framework, Performance Measurement, Supply Chain Design***

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1. Introduction

Companies are critical contributors to the social, environmental and economic well-being of communities (Schaltegger et al., 2006) and many businesses have undertaken various sustainability initiatives for a variety of reasons to mitigate the negative environmental and social impacts of their operations (Carter and Easton, 2011). It is acknowledged that the most important linkage between business and society tends to stem from economic and corporate interests. Banerjee (2008) argues that this reality will persist since organisations, as micro players in the economy, are heavily dependent on achieving economic objectives to remain profitable in the marketplace, while social and environmental welfare tend to be viewed as secondary goals. Accordingly, a genuine change in management theory and the political economy are needed to instigate corporate social responsibility for both business and society (Banerjee, 2008). This highlights the significant complexity inherited between the inter-relationship of environmental, social and economic dimensions, and the importance of power dynamics in business and society. While this warrants a paradigm shift at a macro level (Banerjee, 2008), it could be argued that a more pragmatic and expeditious implementation of sustainability can occur if this shift occurs at both the macro and micro levels, where organisations see themselves at the forefront of sustainability coupled with appropriate measures from the political economy, public sector institutions and society as a whole.

At the supply chain level, the strategic importance of sustainability is also well documented in the literature. Various studies report the increasing number of organisations that have implemented sustainability documentation or voluntary codes of conduct within their supply chains for reporting purposes and performance measurement (Andersen and Skjoett-Larsen, 2009; Keating et al., 2008; Moscardo, 2013; Soosay et al., 2012; Vurro et al., 2009). This extends to the supply chain members that influence the extraction, transportation, production and consumption of materials and products (Gupta and Palsule-Desai, 2011). In this regard, focal organisations and their supply chain members are invoked by pressure for sustainable practices at both organisational and supply chain boundaries. These pressures arise both internally and from external stakeholders, such as customers, shareholders, governments, non-governmental organisations (NGOs) and public authorities. The pervading environmental issues, such as climate change and greenhouse gas (GHG) emissions, and social concerns, such as the use of child labour, have forced many organisations to integrate a wider set of objectives than just reaching an acceptable level of economic performance. Moreover, the introduction of various environmental legislations (e.g. carbon tax) as well as standards and reporting frameworks (e.g. ISO 14000 series, SA 8000 or GRI) would mean that companies at the supply chain level need to balance the three dimensions of social, environmental and economic sustainability (Ashby et al., 2012; Matos and Hall, 2007; Zhu and Sarkis, 2004).

Multidimensional performance assessment frameworks can support corporate activities in coping with institutional and stakeholders' pressures and achieving the firm's long-term strategies. The study by Kaplan and Norton (1996) on the Balanced Scorecard concept acknowledges the benefits of adopting multidimensional approaches to performance management. Balanced Scorecard enables firms to consider non-quantifiable performance measures that can significantly impact the economic success of a business. Figge et al. (2002) introduced sustainability dimensions into a Balanced Scorecard resulting in an integrated performance management tool incorporating the three sustainability dimensions. Brignall and Modell (2000) studied the same issue in a public sector context, and Hubbard (2009) proposed a simple practical sustainable Balanced Scorecard framework to evaluate both quantitative and qualitative performance measures.

There are some common challenges in developing multidimensional frameworks and tools to design and manage sustainable supply chains (Andersen and Skjoett-Larsen, 2009; Gimenez and Tachizawa, 2012). While there have been some efforts assessing environmental sustainability to date, there are still gaps in the current literature in terms of measuring social sustainability and how it can be integrated into sustainability assessment models as well as contemporary

decision-making processes (Carter and Rogers, 2008; Chaabane et al., 2010; Seuring, 2013; Seuring and Müller, 2008; Winter and Knemeyer, 2013; Wu and Pagell, 2011). Various authors advocate the need for the development of assessment frameworks and analytical models that can integrate multiple sustainability measures into supply chain performance (Abbasi and Nilsson, 2012; Björklund et al., 2012; Gupta and Palsule-Desai, 2011; Matos and Hall, 2007; Simpson and Power, 2005). To address this concern and to bridge the gap in the current literature, this paper presents a multidimensional assessment framework incorporating economic, environmental and social performance measures.

To establish the aims of this framework, we review the related sustainable supply chain management literature in Section 2, in particular targeting the underpinning organisational theories which explain sustainability initiatives by organisations. This review helps in identifying the primary drivers and enablers that motivate the development of sustainable supply chains. In Section 3, we present a multidimensional framework incorporating economic, environmental and social performance measures to manage and assess sustainability in supply chains followed by an illustration of a case example in Section 4 to show how the proposed framework can be applied to assist practitioners.

2. Literature Review

2.1 Supply chain management and sustainable development

Supply chain management is the process of planning, executing and controlling the activities and operations of the supply chain efficiently to meet planned objectives (Fahimnia et al., 2011). The design or reconfiguration of a supply chain is considered as a strategic goal aiming at determining the number, location and capacities of manufacturing plants and distribution centres, the set of suppliers to select and the effective flow of material through the supply chain (Chopra and Meindl, 2013; Kaminsky et al., 2004; Simchi-Levi et al., 2008; Vidal and Goetschalckx, 1997). The primary concern in a supply chain design problem is to select those chain members that are integral to fulfilling the long-term broad organisational objectives in achieving superior sustainability goals. We bound the scope of our study to decision-making at this strategic planning level and the framework that we present in this paper aims to provide support during the supply chain design/reconfiguration phase.

Supply chain design and planning involve major business and industrial activities such as materials acquisition, manufacturing, packaging, transportation and recycling, all of which can impose negative environmental and social impacts if not managed appropriately (Fahimnia et al., 2013b; Wisner et al., 2008). The environmental aspects may include GHG emissions, hazardous materials, toxic chemicals and other pollutants as well as land use and resource depletion issues (Sanders, 2012). Governments have been trying to mitigate these issues through enacting tighter environmental regulatory legislations. For example, following the European Commission's mandatory schemes and incentive programmes, the Australian government legislated a carbon tax in 2011 to contribute to the global reduction of carbon dioxide emissions (Thompson, 2012). Another example is China imposing restrictions on the import and manufacture of products containing cadmium or mercury (Wisner et al., 2008).

In addition to the environmental concerns, supply chains increasingly face social performance pressures (Dreyer et al., 2006) and commercial and reputational risks (Carter and Rogers, 2008). Not only can social issues threaten the company's brand image, but they also impact the economic viability of the entire supply chain. Several instances of this nature have been frequently reported in the past, jeopardising the reputation of large multinational corporations such as Wal-Mart, Nike, Gap, H&M and Mattel (Frost and Burnett, 2007) through the violation of union rights and the use of under-aged workers (Andersen and Skjoett-Larsen, 2009). These indicate the significance of overseeing the performance of supply chain partners globally and in integrating economic, environmental and social sustainability objectives.

2.2 Sustainable supply chains, performance management and evaluation

Sustainable supply chain management can be defined as "the strategic, transparent integration and achievement of an organisation's social, environmental and economic goals in the systemic coordination of key inter-organisational business processes for improving the long-term economic performance of the individual company and its supply chains" (Carter and Rogers, 2008). In a sustainable supply chain, the social and environmental impacts need to be mitigated in various geographical regions where upstream suppliers are located, while maintaining financial feasibility of the overall chain (Seuring and Müller, 2008). In situations when a key supply chain player makes a long-term commitment to sustainable development, the downstream and upstream partners will need to comply with the rules of the new structure since their economic viability is dependent on the focal company. This was the case when Wal-Mart discontinued collaborating with suppliers in Bangladesh in 2011 and Uzbekistan in 2008 due to serious misconducts related to sustainable practices (Walmart Global Responsibility Report, 2012). More recently, the importance of this issue has been highlighted when the eight-story Rana Plaza clothing factory collapsed in Bangladesh killing over a thousand workers (Green, 2013). This affected several downstream companies in other regions (Greenhouse, 2013; Manik and Yardley, 2013).

Various authors investigated the linkage between the three dimensions (mainly economic and environmental and partially social) and maintained that the implementation of environmental and/or social initiatives provides potential economic advantage (Carter and Rogers, 2008; Ellen et al., 2006; Golicic and Smith, 2013; Schaltegger and Burritt, 2010; Schaltegger and Synnestvedt, 2002; van Hoof and Lyon, 2013; Wong, 2013; Yusuf et al., 2013; Zailani et al., 2012). For instance, Golicic and Smith (2013) recently conducted a meta-analysis on environmental supply chain management over the past 20 years to determine the positive effects of environmental practices in the supply chain on focal firm performance. Although the meta-analysis did not include the social aspects, the results show that the link between environmental supply chain practices and accounting-based, operational-based and market-based forms of firm performance is positive and significant (Golicic and Smith, 2013). The authors acknowledge the scope for economic gains in addition to meeting regulatory compliance (Golicic and Smith, 2013). There are those who argue that the implementation of environmental or social initiatives seeking to balance the three pillars of sustainability performance can result in substantial costs (Epstein and Yuthas, 2012; Pullman et al., 2009; Ross et al., 2012; Wu and Pagell, 2011). However, focal companies have been able to justify the long-term economic benefits of environmental and social initiatives, and present business cases for sustainable development at the supply chain level (Schaltegger et al., 2011). More sophisticated decision-making tools and techniques are required for firms to perform sustainability assessment across their supply chains (Cousins et al., 2006; Shapiro, 2007; Tan et al., 2002). Such assessment tools and techniques will be dependent on effective performance measurement and management systems (Presley et al., 2007).

Sustainable supply chain management is a new and rapidly evolving area for both research and practice (Ashby et al., 2012). Although the literature stresses that sustainable development at the supply chain level needs to embrace economic, environmental and social performance measures (Sarkis et al., 2010; Seuring, 2013; Seuring and Müller, 2008), most of the published works have primarily dealt with one or two dimensions in isolation (Ashby et al., 2012; Pagell and Wu, 2009; Seuring and Müller, 2008). Green or environmental supply chain management has gained much more attention as compared to the social aspect (Carter and Easton, 2011; Miemczyk et al., 2012; Sarkis, 2012). We aim to address this important gap in the current literature and propose a framework that can be used as an assessment tool for the design of sustainable supply chains, especially assisting in supplier evaluation and selection activities. Before presenting this framework, we first identify the drivers and enablers for developing sustainable supply chains grounding the development in organisational theories.

2.3 Theoretical basis for sustainable supply chain management

Organisational theories describe and justify the behaviours, design or structures of firms (Sarkis et al., 2011). Carter and Easton (2011) explored studies in sustainable supply chain management from 1991 to 2010 and found their incorporation of various theories, particularly stakeholder theory and resource-based theory (RBT), to underpin their research. Sarkis, Zhu and Lai (2011) reviewed the green supply chain management literature and arrived at a similar conclusion. They identified nine theories that are relevant to sustainable supply chain management: resource-based, stakeholder, institutional, social network, resource dependence, information, ecological modernisation, transaction cost economics and complexity theories. Examining such perspectives can help identify the drivers for sustainability initiatives and provide insights on how organisations can benefit from internal and external factors to develop sustainable supply chains (Rungtusanatham et al., 2003).

For the purpose of this paper, we examine four theories namely resource based, institutional, stakeholder and social network theories to identify how factors from these theoretical underpinnings drive and enable the broad adoption and development of sustainability practices at the supply chain level. These four theories provide both internally- and externally-oriented underpinnings that can serve to identify elements for sustainable performance evaluation and monitoring. These elements can be effectively integrated through an explanation of drivers and enablers used in later stages. Although other theories can be integrated, the literature has shown an overlap and integration of these theories in different couplings to explain various sustainable supply chain phenomena. For example, the linkage of institutional, stakeholder and resource based theories have been shown to complement each other (Sarkis et al., 2010). Also, some recent advances in RBT support the linkage to systemic and social network theory (Priem and Swink, 2012).

The overlapping and complimentary characteristics of these four theories provide support for a multidimensional, strategic perspective for SSCM. Institutional theory posits a number of competitive pressures and the response to multiple internal and external stakeholders (stakeholder theory), while RBT supports the combination of resources that span across firms in addressing these competitive pressures. Such resources depend on the interdependencies, linkages and exchange relationships between firms (social network theory) to achieve sustainable outcomes and competitive advantage. Thus, the linkage of these four theoretical perspectives with their overlapping and complementary views can provide significant insight into the need and application of multidimensional performance evaluation for SSCM. Additional detail on each of these theories and relationships are further elaborated below.

2.3.1 Resource-Based Theory (RBT)

The RBT suggests how valuable, rare and inimitable resources can become the basis for competitive advantage of firms (Barney, 1991). Resources refer to assets, capabilities, competencies, process and knowledge which are controlled by a firm to implement strategies and improve competitiveness (Amit and Schoemaker, 1993; Barney, 1991; Grant, 1996; Prahalad and Hamel, 1990). Hart (1995) introduces the natural resource based view of organisations, highlighting the sustainability risks and opportunities, and discusses how environmentally and socially sustainable economic activities can build competitiveness for organisations. Sustainability initiatives such as environmentally-friendly production lines can lead to long-term sustained competitive advantage for firms (Connelly et al., 2011).

RBT in general supply chain management research has also been recently advanced. For example, the issue of whether supply chain resources are only based on upstream and internal resource development has come under increased scrutiny (Priem and Swink, 2012), where it is argued that resources are meant to be also considered from the downstream (demand) side of supply chains and how these resources play a role in building competitive advantage. Further, the support for utilising RBT within supply chain management arose from criticism that RBT is not applicable to supply chain management and purchasing (Hunt and Davis, 2008; Ramsay,

2001). Barney (2012) stipulates that strategic factor market theory or the attributes of resources aspect of RBT fit within the use of supply chain management as a competitive weapon (Barney, 2012). The recent arguments by Priem and Swink (2012), Barney (2012) and Hunt and Davis (2012) indicate that a systems perspective of resources can benefit the RBT application at the firm and supply chain levels. RBT thus provides a good point of evaluating sustainability resources in supply chain management.

Recently, there have been efforts to more specifically realise the relationship between the RBT and sustainable supply chain management (Gold et al., 2010; Pagell et al., 2010; Rao and Holt, 2005). The processes, knowledge and capabilities that enable a supply chain to become environmentally and socially sustainable can be viewed as organisational resources from the perspective of RBT (Sarkis et al., 2011). Sustainable practices enhance the organisation's image and reputation, which is a significant resource in the supply chain, and further improve the marketability of products and services (Sarkis et al., 2011; Shang et al., 2010). This is critical as supply chains are a collection of interrelated organisations competing against other supply chains, as opposed to stand-alone organisations (Ketchen and Hult, 2007). Additionally, the 'culture' of the supply chain being socially and environmentally sustainable could also be a source of sustained competitive advantage. From this argument, the development of a truly sustainable supply chain can be seen as a valuable resource which could provide a competitive advantage (Hunt and Davis, 2008).

2.3.2 Institutional Theory

Institutional theory describes how institutions (e.g. governments, media and public associations) use pressure to impact organisational behaviour and decision-making, and how such pressure gradually create institutional rules (Meyer and Rowan, 1977; Oliver, 1991). Organisations seek survival and legitimacy by conforming to critical institutional rules which stem from coercive, mimetic and normative isomorphic drivers (DiMaggio and Powell, 1983; March and Olsen, 1984). Coercive isomorphism explains the organisation's response to pressure exerted from those in power (i.e. government and regulators) with those whom the organisation is linked to (Sarkis et al., 2011). Mimetic isomorphism occurs in uncertain business environments, when organisations imitate other successful and legitimate organisations to reduce cognitive uncertainty (Connelly et al., 2011). Normative isomorphism is associated with professionalism and organisational shared norms (Zhang and Dhaliwal, 2009).

From this viewpoint, some authors argue that sustainability initiatives can ensure an organisation's legitimacy and social approval to a large extent (Bansal and Roth, 2000; Russo, 2002; Sandhu, 2012). However, it is widely acknowledged that the sustainability initiatives, either based on compliance or proactive strategies, should extend beyond the organisational boundaries and be implemented across the supply chain (Ciliberti et al., 2008; Neto et al., 2008; Peters et al., 2011; Vachon and Klassen, 2008; Zhu and Sarkis, 2004). Organisations that comply with standards, legislations and societal norms not only enhance the likelihood of their strategic survival, but are also secured against the possible consequences of environmental and social misconduct including penalties, protests, campaigns and sanctions (Peters et al., 2011; Videras and Albertini, 2000). In the case of Wal-Mart, the company faced significant criticism when it was discovered that their upstream suppliers were using child labour in Bangladesh and Uzbekistan (Andersen and Skjoett-Larsen, 2009). Developing institutional norms in regard to sustainability issues requires the appropriate tools and techniques to formulate and measure the organisation's performance in the three areas of sustainability.

2.3.3 Stakeholder Theory

Stakeholders can influence organisations to follow specific actions including sustainability initiatives and voluntary integration of sustainability into business operations (Rowley, 1997; Russo and Perrini, 2010; Vurro et al., 2009). Different classifications of stakeholders exist with various degrees of contribution or significance (Sarkis et al., 2011). In one classification, stakeholders can be grouped as primary or secondary stakeholders (Clarkson, 1995). However,

this classification may change over time (Sandhu, 2012). For example, the predominance of environmental groups and agencies plays a more significant role in influencing the behaviour of firms today than in the past (Hart and Sharma, 2004). Mitchell et al. (1997) further present a classification based on the dimensions of power, urgency and legitimacy to help unpack stakeholder saliency. With regard to these three attributes, the spectrum of stakeholders starts with definitive stakeholders on one side and ends with non-stakeholders on the other side (Mitchell et al., 1997).

Stakeholder theory has been the most cited and discussed theory in the sustainable supply chain management literature (Carter and Easton, 2011). Vast research has investigated stakeholder influence on the adoption of social and environmental practices across supply chains (de Brito et al., 2008; González-Benito and González-Benito, 2006; Maignan and Mcalister, 2003; Matos and Hall, 2007; Sarkis et al., 2010). For instance, González-Benito and González-Benito (2006) investigated the role of stakeholder pressure in the implementation of environmental practices at the supply chain level. In analysing 186 case examples, they found that only non-governmental pressure can explain the implementation of environmental practices. Additionally, Sarkis, Gonzalez-Torre & Adenso-Diaz (2010) proposed a theoretical framework based on the integration of stakeholder theory and RBT to investigate the relationship between stakeholder pressure and the adoption of environmental practices within the Spanish automotive industry. A common finding in this context is that typically firms need to relentlessly improve capabilities and adopt strategies to meet the requirements of their key stakeholders. This explains how the sustainability commitment of stakeholders can be the primary driver for the adoption of sustainability practices at the supply chain level.

2.3.4 Social Network Theory

A social network is a set of organisations interlinked by a series of relationships which can be graphically illustrated by a set of nodes and lines (Chabowski et al., 2011). Multiple and interdependent interactions between organisations were explored by Rowley (1997) who applied social network models to the stakeholder research to investigate the reasons for organisational resistance to stakeholder expectations. According to Rowley (1997, p.894), "the primary focus of social network analysis is the interdependence of actors and how their positions in networks influence their opportunities, constraints, and behaviours". The two key elements of this theory include density (the completeness of the ties between the actors in a network) and centrality (the position of a company in a network and its ability to control the information flow) (Rowley, 1997; Sarkis et al., 2011).

Due to increasing cross-enterprise decision-making approaches adopted in supply chain management, the social network theory is instrumental in examining the structure of interorganisational relations (Carter et al., 2007; Handfield, 2002). This theory has been used to study the interaction between organisations at both dyadic and macro structural levels, where researchers have focused on interlocking directorates as well as interorganisational communication and resource exchange (Borgatti and Foster, 2003; Brass et al., 2004; Galaskiewicz and Wasserman, 1993; Mizruchi and Galaskiewicz, 1993). Although it could be argued that constructs of the social network theory can largely help analysts explore relationships between supply chain members at both mentioned levels, there have been very few studies that employ this theory in the supply chain management context to date (Carter et al., 2007; Phillips and Phillips, 1998; Sarkis et al., 2011).

The social network theory can be used to validate the necessity of collaborative practices in supply chains and further describe the need for undertaking sustainability initiatives (Lee, 2005; Sarkis et al., 2011). Social networks enable effective implementation of sustainability practices in which a focal company can benefit from its central position to champion and monitor sustainability initiatives (Vurro et al., 2009) through both "hard" material/money flow types of ties and "soft" alliances and sharing-of-information types of ties (Borgatti and Li, 2009). A focal company reviewing the design of its supply chain configuration may consider the employment

of advanced information sharing mechanisms that can increase supply chain density and in turn its ability to undertake sustainability initiatives (Neville and Menguc, 2006; Vurro et al., 2009).

2.4 Drivers and enablers of sustainable supply chain management

Based on these four organisational theories discussed, we identify key drivers and enablers that motivate and influence the sustainability practices in supply chains and in creating a business case for sustainability. (1) From an organisational perspective, the resources including assets, capabilities, competencies, processes and know-how are necessary to implement strategies and improve competitiveness both at the firm and the supply chain levels. The effective utilisation and sharing of resources and capabilities between the supply chain entities, as posited by more recent RBT thought, e.g. Priem and Swink (2012), can be seen as a competitive advantage that enhance the implementation of sustainable practices across the supply chain. (2) Macro-level sources of institutional pressures can influence businesses and supply chains to adopt more socially and environmentally responsible practices. These stem from state regulations, industrial self-regulation, monitoring organisations (e.g., NGOs, institutional investors and the media), business publications and education, trade or employer associations, and formal processes of stakeholder engagement (Caprar and Neville, 2012; Zhu et al., 2013). The institutional perspective elucidates what drives the spread of sustainability principles within and between firms in the chain, and also why the adoption varies in different economic settings. (3) Organisations are compelled to satisfy the interests of their primary stakeholders to ensure the viability of their business operations. Central to the stakeholder theory interpretation is that these demands and expectations of stakeholders should be considered as an input for implementing and managing sustainable supply chains (Golicic and Smith, 2013). (4) A supply chain can be viewed as a social network comprising interrelated organisations whose success depends on the systematic integration of business processes and collaborative performance of supply chain entities. Effective information exchange between supply chain participants can enhance the implementation of sustainability practices.

From these statements, it can be argued that the motivations for the development of sustainable supply chains may arise from both internal sources (e.g. internal stakeholders, customers, management, suppliers and retailers) and external institutions. We term these as ‘Drivers’. Additionally, the development of a sustainable supply chain is reliant on the synergistic combination of resources (tangible and intangible) of the participating firms coupled with the design of an effective supply chain structure that promotes global coordination and information sharing between supply chain members. The resources can also be supported with various organisational capabilities (Lee and Klassen, 2008), with capabilities defined as both internal and external capabilities. For example, a focal organisation may be dependent on environmental capabilities of its suppliers to produce green products, and internal training capabilities to help address labour issues in an organisation. We term these as an Enablers category. Both these drivers and enablers can help firms identify weaknesses and inhibitors. Notwithstanding these factors, firms are also able to discern the respective issues and challenges through their inability to complete enabling activities, lack of resources, coordination, collaborative efforts or poor planning to achieve sustainability in their supply chains.

Unlike Carter and Rogers (2008), the focus here is less on utilising sustainability’s triple-bottom-line intersections to identify enablers, and utilise organisational theories to help identify characteristics of enablers and drivers. Although many drivers and enablers for environmental and socially responsible supply chains have been identified in the literature (Diabat and Govindan, 2011; Lee and Klassen, 2008; Walker et al., 2008), much of their development and identification was based on practice and literature. The explicit linkage of these drivers and enablers to underlying organisational theories was not evident in this literature.

3. A framework for sustainability development and assessment

A framework for comprehensive sustainability management and assessment requires the consideration of economic, environmental and social objectives and performance measures (Salzmann et al., 2005; Schaltegger et al., 2011). However, given the complexity of a supply chain involving a number of participating firms, it may be impractical to take into account every single aspect of sustainability when developing an assessment framework (Hubbard, 2009; Matos and Hall, 2007). Based on an empirical study, Matos and Hall (2007) advocate that having a broad integrated approach to examine interactions amongst environmental, economic and social dimensions is better than applying deep, but disconnected expertise in each one, particularly in the environmental dimension. Likewise, Pagell and Wu (2009) note that truly sustainable supply chains may not exist. Therefore, sustainability assessment will have its limitations to some extent. The framework that we present aims to incorporate some of the primary aspects of supply chain sustainability in line with the triple bottom line concept. The sustainability measures presented in our framework are collected from the existing literature on sustainable supply chain management as well as the broadly-adopted Global Reporting Initiative (GRI) sustainability guidelines (GRI, 2012).

3.1 Incorporation of economic and business performance measures

Various studies employing supply chain modelling have traditionally focused on the economic aspects of the network with cost minimisation (or profit maximisation) and service level maximisation being the most predominant objectives (Fahimnia et al., 2013a; Shapiro, 2007). We follow the same line of thinking and incorporate supply chain cost and service level as the basic economic and business performance measures in our framework. Supply chain costs may include the cost of procurement, production, opening and operating facilities as well as transportation and storage costs (Chaabane et al., 2012; Fahimnia et al., 2013c). Backordering or backlog costs and the cost of lost sales have also been regarded as the primary measures of service level and customer satisfaction (Fahimnia et al., 2013d). Additional factors for supply chain business performance can be derived from the existing literature of supply chain performance measurements (Gunasekaran and Kobu, 2007). For example, not listed in the diagram, other business and economic performance measures can be defined based on balanced scorecard dimensions, supply chain operations reference (SCOR) model, and tangibility and intangibility categorisations (Bai and Sarkis, 2011).

3.2 Incorporation of environmental performance measures

Some of the important environmental concerns in the literature on supply chain management include GHG emissions (Paksoy et al., 2011), waste generation (Tsai and Hung, 2009), energy consumption (Cholette and Venkat, 2009), water usage (Brent, 2005) and the use of hazardous and toxic substances in products (Hsu and Hu, 2009). Environmental performance measures may exist at multiple levels and include localised, regional and global environmental performance measures. They can also be targeted to specific media, such as air, water or solid waste. The listing of environmental indicators that can be used as performance measures can be quite extensive and is evidenced by journals dedicated to the development of ecological indicators. Given the extensive listing of environmental performance measures, the issue of GHG emissions has been stressed in the literature as the most prominent because of their significant consequences on ecosystems and human health, which in turn has led to the introduction of several emission-control regulatory policies worldwide (Gupta and Palsule-Desai, 2011; Paksoy et al., 2011).

Factors contributing to the Earth's climate change can be classified into natural and anthropogenic (human-induced) factors. GHGs are the main cause of anthropogenic climate change of which carbon dioxide (CO_2) is referred to as the most harmful (GRI, 2012; Gupta and Palsule-Desai, 2011). The Intergovernmental Panel on Climate Change (IPCC, 2012) reports

that "most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations". Accordingly, the Kyoto Protocol implemented in 2005 as the predominant international agreement to stabilise GHG emissions and consequently, several countries have introduced taxation regulations from taxing/pricing carbon to cap-and-trade schemes to comply with the Kyoto protocol through monitoring and controlling emitted GHG (Gupta and Palsule-Desai, 2011). Not surprisingly and as a response to this trend, the issue of GHG emissions is one of the most frequently mentioned topics in the sustainable supply chain management literature (Benjaafar et al., 2013; Elhedhli and Merrick, 2012; Ramudhin et al., 2010; Seuring, 2013).

Using this rationale, our framework refers to GHG emissions as a primary environmental performance measure. In presence of environmental regulations (e.g. carbon pricing/trading schemes), the amount of GHGs emitted in procurement, manufacturing, storage, and in-bound and out-bound transportation can be converted into the equivalent emission cost (Chaabane et al., 2010; Pishvaee et al., 2012). Emission cost can be calculated using the Emission Factor Data Base (EFDB, 2012) developed by the Intergovernmental Panel on Climate Change (IPCC, 2012). Other environmental factors including water usage, energy consumption and waste generation can also be expressed in form of equivalent costs incurred. A weighted or scoring approach can be adopted in situations when such costs represent only a small portion of the overall supply chain cost causing a slight influence on the associated supply chain strategies. The weighted approach presented in Section 3.3, primarily aiming at the incorporation of social performance measures, can also be used to assess the environmental performance of the chain members. This way, the environmental performance metrics such as emission generation, water usage, wastes, energy consumption, and the use of hazardous and toxic substances will replace the social items in the proposed weighted approach.

3.3 Incorporation of social performance measures

To the best of our knowledge, practical modelling efforts incorporating social sustainability measures along with environmental and economic factors are virtually non-existent (Carter and Easton, 2011; Carter and Rogers, 2008). It is argued that social performance measures are difficult to quantify and incorporate in supply chain assessment models (Chaabane et al., 2010, 2012; Seuring, 2013). We introduce a unique assessment tool to quantify and score the social performance of supply chain participants. We adopt a weighted approach to score the supply chain performance in four primary social dimensions (introduced by GRI) including labour practices and decent work conditions, human rights, society, and product responsibility (GRI, 2012). The four categories are also congruent with the guidelines of Social Accountability 8000 (SAI, 2008), Universal Declaration of Human Rights (UNHCHR, 1997), International Labour Organisation (ILO) and the social life cycle assessment (Dreyer et al., 2006, 2010; Hauschild et al., 2008).

A score is assigned to each supply chain member based on its performance against the available codes of conducts in four primary social areas. For the weighting, a pairwise comparison scale, first introduced by Saaty (1990) for the analytic hierarchy process (AHP), is used. AHP has been extensively applied in the literature to analyse and compare alternative decision scenarios (Handfield et al., 2002; Ho, 2008; Lin and Juang, 2008; Opasanon and Lertsanti, 2013; Sarkis, 1998; Wang, 2011). We propose a simplified version of this approach, using Saaty's comparison model for the assessment of supply chain social performance (see Table 1). The unit difference between successive scales in Table 1 is based on the well-known psychological theory presented by Miller (1956). The total number of scales is determined noting that most individuals cannot make a comparison among more than seven objects, plus/minus two, simultaneously (Saaty and Ozdemir, 2003; Wang, 2011).

Table 1. The proposed pairwise comparison scale

Score	**Degree of conformance** (variation between social guidelines and the actual performance)
1	No variation
3	Weak variations
5	Essential or strong variations
7	Demonstrated variations
9	Absolute variations
2, 4, 6, 8	Intermediate values between two scores

Using the comparison scale presented in Table 1, every supply chain member receives *four* scores (in the scale of 1-9) reflecting its performance against the focal company's social guidelines in GRI's *four* social dimensions. The larger a score is, the greater would be the deviation from the established standards (i.e. the worse the social performance). Once the four scores are assigned to each supply chain member, the summation of the four scores for each supply chain member determines the overall violation of that member against the social guidelines. Obviously, members with the lower overall scores are the better performing candidates in terms of social performance. The next step is how to incorporate these scores in a supply chain planning and optimisation model. In mathematical models, the weighted scores can act as social performance coefficients used in formulating 'social violation minimisation' constraints. Such constraints will then help in analysing and comparing alternative supply chain configuration scenarios with respect to their associated social risk.

As described earlier, this scoring approach can also be used to assess the environmental performance of the chain members. In this case, the key environmental performance metrics can replace the four social performance measures. In other words, in situations when social or environmental impacts and measures are not easily convertible to equivalent dollar values, a scenario-based approach can be utilised in which multiple solutions/scenarios are developed, each with a specific supply chain cost and associated environmental and social impacts. An optimal solution to such a problem would be case-specific depending on the existing budgetary constraints and the social and environmental goals of the focal company. Scenario-based modelling approaches have been adopted in some of the past studies providing important insights for seeking sustainability trade-offs in complex supply chains (Abdallah et al., 2011; Bai and Sarkis, 2010; Bojarski et al., 2009; Chaabane et al., 2012; Guillén-Gosálbez and Grossmann, 2010; Nagurney and Yu, 2012; Neto et al., 2008; Paksoy, 2010; Pinto-Varela et al., 2011; Seuring, 2013).

The overall structure of the proposed framework is illustrated in Figure 1 incorporating the aforementioned economic, social and environmental performance measures.

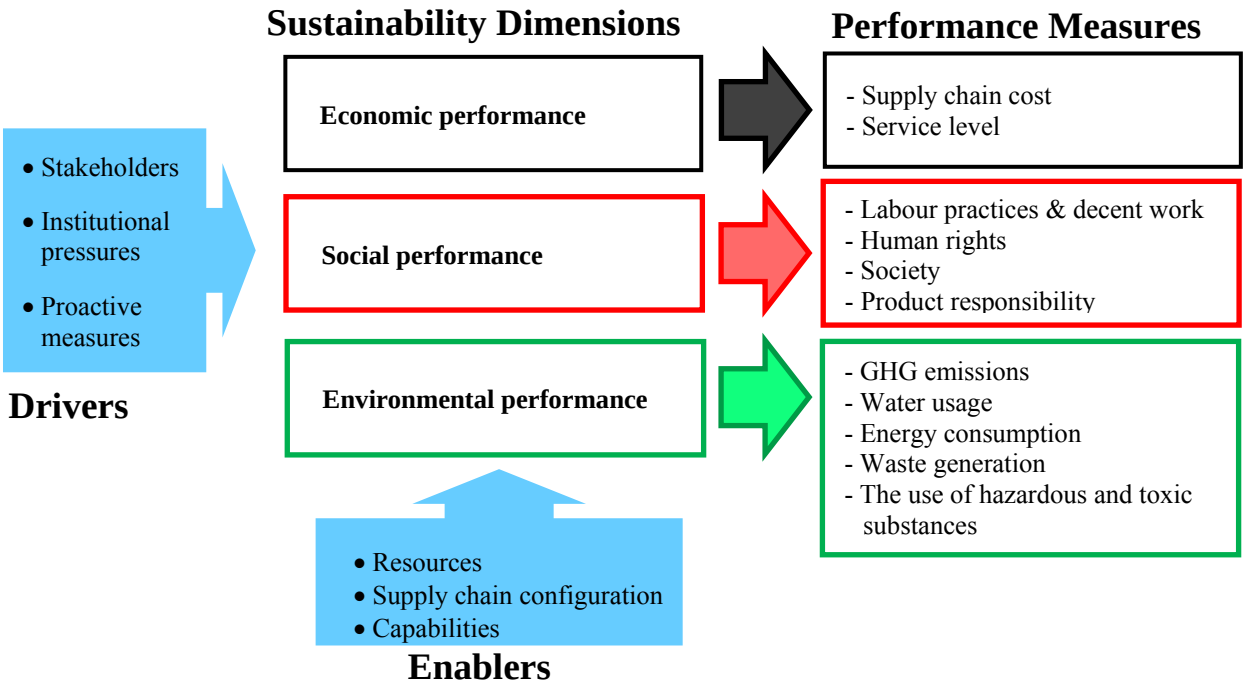

Figure 1. Foundations of the proposed assessment framework

4. Framework illustration: A case example using optimisation techniques

Supply chain decisions at the strategic level are often irreversible and hence their potential impacts must be carefully investigated before the actual implementation. Optimisation and simulation techniques have been used as effective tools to examine the consequences of such decisions on supply chains (Shapiro, 2007). The use of optimisation models for strategic supply chain development has considerably increased in recent years to study trade-offs among multiple objectives (Chaabane et al., 2008; Ramudhin et al., 2010). A multi-objective optimisation model can assist in evaluating the interplay between economic, environmental and social objectives of a supply chain (Fahimnia et al., 2009; Sarker and Newton, 2008) and suggest the optimal configuration of a sustainable supply chain. Such tools can help in designing and managing supply chains and identifying those areas across the supply chain where strategic investments need to be made.

Similar to the approach adopted by Hutchins and Sutherland (2008) and Svensson (2007), we provide a conjectured example that demonstrates how our assessment framework can be utilised in an optimisation model for a focal organisation seeking to incorporate sustainable measures when expanding its supply chain operations globally. Most of the data that we use in this case example is based on the general observations and practical experiences of the authors; a good replication of a sustainable supply chain design situation a case company may face in reality. Consider an Australian company involved in the production and distribution of sportswear products with one local manufacturing plant, one local distribution centre and a set of nationally-dispersed retailers. Various drivers such as rising costs, shareholders' concerns and management strategy in the Australian operations have caused the company to evaluate the construction of new facilities in Asia to supply Australian and potential overseas markets. The recently introduced carbon pricing scheme in Australia and the pressures from stakeholders and social campaigns are the motivations to incorporate sustainability factors in supply chain reconfiguration decisions (Frost and Burnett, 2007; Mower, 2012; Playfair, 2012; Thompson,

2012). We show how our framework can assist the company to both examine its current operations and make investment decisions in its supply chain reconfiguration.

Recent investigations by the supply chain analysts have revealed that the company may benefit substantially from using the resources and technical knowledge of foreign firms to manage its overseas operations. To satisfy the potential market demands in Australia, Asia and the U.S., the company requires alliances with four medium-sized manufacturing plants. It also involves the selection of the appropriate raw material suppliers to feed the plants as well as distribution centres for sorting and storing products for full truckload coordination purposes. The initial audits and cost analyses have shortlisted nine potential manufacturers from four different countries. These include plants *A*, *B* and *C* in Indonesia, plants *D* and *E* in Sri Lanka, plants *F* and *G* in Cambodia, and plants *H* and *I* in Thailand. Four candidate suppliers of these manufacturing plants include suppliers *X* and *Y* in Pakistan and suppliers *Y* and *Z* in India. There are also four candidate distribution centres including warehouse *K* and *L* in Malaysia and warehouse *M* and *N* in Indonesia. The objective is to find the optimal configuration of the new supply network that minimises the overall system costs as well as the negative environmental and social impacts.

The economic assessment is carried out using documented financial reports and price/cost analysis for each candidate supply chain member including manufacturers, raw material suppliers and warehouses. Supply chain cost components may vary from one company to another, but the more common components include the direct and indirect costs of material, parts and components, costs of opening and operating manufacturing plants and distribution centres, as well as holding and transportation costs (Fahimnia et al., 2012; Fahimnia et al., 2008). The environmental dimension is assessed in terms of GHG emissions generated by suppliers, manufacturers and warehouses as well as the associated transportation emissions. Emission estimation requires various supply chain parameters that can be obtained from the Emission Factor Data Base (EFDB, 2012) established by the United Nations Environment Program (UNEP). This involves determining the amount of GHG emitted in various supply chain processes per unit of product (Chaabane et al., 2010). Additional environmental costs may include the costs of water usage, energy consumption and waste generation.

For social assessment, data needs to be collected through supplier audits, that is visiting facilities, interviewing the key personnel, and investigating the guidelines and related reports of the candidate members (Dreyer et al., 2010). Referring to the assessment procedure described in Section 3, every candidate member (manufacturers, raw material suppliers and warehouses) is allocated a score (scaling between 1 and 9) reflecting its performance against the social items set by the focal company. Table 2 shows the process of scoring the candidate manufacturers for the case company under investigation. The results indicate that plants *B*, *C*, *H* and *I* are the lower-risk choices in terms of social performance while manufacturers in Sri Lanka and Cambodia show poorer social performance. Identical analyses need to be performed for the social assessment of suppliers and warehouses. This weighted approach allows the incorporation of the social dimension for sustainable supply chain reconfiguration.

Table 2. Scoring of candidate manufacturers – A case example

Social items	**Manufacturers**								
	Indonesia			Sri Lanka		Cambodia		Thailand	
	A	B	C	D	E	F	G	H	I
Labour practices and decent work	6	2	2	8	7	5	8	4	2
Human rights	7	2	2	8	8	7	7	3	2
Society	5	1	3	5	5	7	7	3	2
Product responsibility	5	3	3	7	6	5	5	4	3
Total score	**23**	**8**	**10**	**28**	**26**	**24**	**27**	**14**	**9**

Using the overall supply chain cost (including the costs of procurement, production and distribution as well as the associated emission costs) and the social scores of suppliers, manufacturers and warehouses, a multi-objective optimisation model can be developed in which the goal (objective function) is to minimise the overall supply chain costs awhile minimising the negative social impacts expressed in a 'social violation minimisation' constraint. Referring to the scenario-based analysis discussed in Section 3, the proposed model in this case minimises the value of the objective function for a range of social performance scenarios. A decision maker is then able to choose a scenario/solution given the existing budgetary constraints and the social and environmental goals of the focal company. This is how the three sustainability goals can be incorporated into a single integrated optimisation model.

5. Discussion and Conclusions

Sustainable supply chain management is an emerging area for both research and industry practice. The established notion of the triple bottom line in enabling economic benefits through improving social standards and preserving the environment for future generations is well accepted and gradually pervading the business arena. Businesses require assessment frameworks and decision tools to measure and balance the supply chain performance in three sustainability dimensions. While various assessment models are available in the existing literature, these do not always address the three dimensions of sustainability, possess methodological issues or are developed for the organisational level only. In hindsight, this paper offers a relatively simple, yet practical approach for the design of sustainable supply chains, focusing on facility location and supplier selection decisions, and offers several contributions to both theory and practice.

5. 1 Theoretical contribution

Through a review of the literature and the integration of concepts from four organisational theories, we identify key drivers and enablers in the development and management of sustainable supply chains. It is essential for supply chains to consider who their stakeholders are and the interrelationships between supply chain members, resources, activities and interfaces comprising coordination, interaction, cooperation and competition. These may include internal stakeholders such as shareholders, employees and trade unions and external stakeholders such as customers, suppliers and other partners, competitors, government and regulators, NGOs and interest groups, and local and international communities (Bendell, 2003). From a resource base viewpoint, firms will need to ensure that they have the potential to implement sustainability in terms of cost, quality and culture. Secondly, embracing social or green production methods can incur large cost outlays, hence requiring financial investments in resources and manufacturing capabilities. Additionally, with the selection of compatible suppliers, the supply chain can foster

an appropriate culture and conformance to agreed codes of conduct (Gopalakrishnan et al., 2012). Notwithstanding the supply chain as a network of organisations, sustainable development can be achieved with collaborative efforts and a participative governance model. All things considered, we offer a multidimensional framework that incorporates multiple performance measures in economic, environmental and social dimensions. Moreover, given that practical modelling efforts incorporating social sustainability measures are virtually non-existent, we introduce a new methodology for quantifying the social performance of supply chain members. This aspect is novel in the field and has not been explored in previous empirical works; thereby bridging the gap in the literature and addresses the call for an integrated approach (Seuring, 2013; Tang et al., 2008; Winter and Knemeyer, 2013).

5. 2 Implications for Supply Chain Management

The proposed framework and performance assessment methodology can assist supply chain management and decision-making at various levels. The strategic and long-term objective of any sustainable supply chain would be optimising the best possible configuration of suppliers, manufacturers, distribution centres and logistics providers. Our framework enables the multidimensional assessment of supply chain members based on the simultaneous consideration of economic, environmental and social goals. Decisions can be made about (1) number, location and capacities of manufacturing plants and distribution centres, (2) the strategic selection of suppliers for the acquisition of raw materials and components, and (3) the optimal flow of material from suppliers to the demand points. The example as illustrated above highlights this.

Additionally, the framework can be applied in existing or established supply chains. At the tactical level, the multidimensional framework serves as an intermediate tool in determining where interventions are mandated in the chain, in terms of economic, social and environmental performance of each member. This approach assists supply chain managers identify whether partners are interpreting and pursuing commercial opportunities beyond economic objectives or reducing the chain's long-term exposure to risk. Essentially, if partners' values are aligned with the focal company's goals, then sustainable development might be achieved more efficiently through establishing and promulgating the ethos and codes of conduct in sustainable operations. This ethos would furthermore encourage the development of commercial strategies predicated on the embracement of such values. Our framework also provides support for periodic supply chain disclosure and sustainability reporting based on the multidimensional assessment of supply chain members. We argue that focal firms from time to time would need to review their strategies, processes and activities related to the supply chain, as well as continued monitoring of sustainability performance.

While this multidimensional framework is a tool for developing and managing sustainable supply chains, the onus subsequently lies with supply chain managers and decision makers to identify with the sustainability agenda, where the constraints or weaknesses are within organisations, and undertake appropriate measures to achieve a balance between economic, environmental and social objectives for the supply chain.

5. 3 Research Limitations and Future Research

As with any study, research limitations exist, but these limitations can provide guidance for future research directions. An initial limitation is that the model and characteristics, although generalisable to an extent due to the general theories, would require further validation. A prescriptive application through a normative model can provide evidence of the utility of the model, but broader evaluations through numerous in-depth case studies and/or broad-based survey applications to identify specific and acceptable groupings of drivers and enablers.

Even though four theories were utilised to provide the necessary theoretical foundation for this work, given the implication of this research at various organisational levels, these initial theories need further investigation and comparison, and possibly integration, at the various levels. For example, competing theories (see Sarkis et al., 2011), such as transaction cost theory which

focuses on asset specificity as a potential characteristic of both the relationships and resources, may play a role in further refining and expanding the model.

This study and framework development relied on organisational theory for model support and development. Individual level, behavioural psychology or information systems adoption theory could be investigated. Cognitive decision-making theory (e.g. Miller, 1956) was briefly mentioned in this paper, but additional and more recent insights into decision making behaviour and theory may be necessary to help adjust the application of the model. For example, research investigation on behavioural adoption and usage of any sustainability decision making tool, not just the one presented here, is virtually non-existent. The adoption of these decision tools can be informed from theory in psychological motivational pro-environmental behaviour (e.g. (Graves et al., 2013) or an information systems adoption theory for decision support systems such as the technology acceptance model (e.g. (Davis et al., 1989; Gholami et al., 2013).

The proposed framework, although easily implementable due to its relatively straightforward and flexible characteristics, can be further enhanced through a variety of multiple criteria approaches and advances. For example, integration of the tool with other multiple criteria evaluation techniques such as outranking, TOPSIS, and multi-objective mathematical programming can possibly be pursued (see Seuring (2013) and Govindan et al. (2013) for a review of various additional modelling approaches). Even if integration is not possible, further validation of the framework needs to occur, either through simulation or actual application. A comparative analysis with other tools would be beneficial to further identify the strengths and weaknesses of the framework and eventual improvement. This study and framework set the stage for addressing the many gaps in sustainable supply chain performance evaluation and decision modelling. We believe that this area still requires significant investigation as these managerial decision tools, at the operational and strategic level, will guide industry and supply chain sustainable progress and improvement.

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