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The effect of early supplier engagement on social sustainability outcomes in project-based supply chains



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ABSTRACT

This work uses a mixed methods research design to explore how social sustainability outcomes are impacted by early supplier integration and associated strategies for successfully implementing this integration. Much of the literature in the area focuses on environmental factors, while social sustainability factors such as worker and consumer safety have been underrepresented. The results quantitatively illustrate the positive effects on sustainable outcomes of making environmental, health, and safety (EHS) a decision factor earlier in the product lifecycle and of using early supplier involvement as an implementation strategy to accomplish this goal. More importantly, the results show that the suppliers that are being involved early are not always strategic suppliers as one would expect, but are often what are traditionally categorized as leverage suppliers. These results are relevant because they not only align with recent research in sustainable sourcing management, but also have practical implications for organizations trying to be successful in a triple bottom line environment.

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1. Introduction

Whether it is through the lens of the triple bottom line, corporate social responsibility, integrated lifecycle management, or sustainable supply chains, there has been an increased focus in literature and practice on a broad perspective in which factors other than profit are important drivers of decision-making in the supply chain (Kleindorfer et al., 2005; Lindgreen and Swaen, 2010). One key element of these concepts is the recognition that the planning and implementation of such a strategy is largely an external activity, and firms must cooperate with stakeholders both upstream and downstream in order to achieve success. More specifically, research has discussed how addressing triple bottom line (TBL) issues during sourcing decisions should be an important component of an organization's social responsibility strategy (Carter and Jennings, 2004), as well as the performance benefits observed when upstream stakeholders are engaged early in environmental sustainability issues (Lee, 2008; Ofori, 2000).

Reviews by Kleindorfer et al. (2005) and Seuring and Müller (2008) have found that much of this research in the supply chain management domain has focused on the environmental aspects of sustainability and largely ignored social aspects. The social portion of the TBL is concerned with incorporating the impacts of products and services on stakeholders and consists of issues such as worker health and safety, human rights and equity, and basic needs fulfillment (Dreyer et al., 2006; Hutchins and Sutherland, 2008). Thus, there is an opportunity to assess how earlier integration of upstream stakeholders, such as suppliers, on social issues would generate performance benefits similar to those found through early supplier engagement on environmental issues. Early supplier engagement in this regard is defined as the involvement of a supplier organization in conceptual and design activities (Smith and Zsidisin, 2002).

The construction industry presents an opportunity to study the impact on supply chain level outcomes of considering social sustainability issues during the sourcing process. The social issue of worker safety is a relevant topic in this industry, as the construction industry had the highest number of fatalities, the fourth fatality highest incident rate, and a lost time rate (all common safety metrics) above the overall industry average of the United States in 2012 (Bureau of Labor Statistics, 2013a, 2013b). Incidents outside the construction industry, such as a deadly building collapse in Bangladesh of a supplier for Wal-Mart, Gap, and other major retailers (Mauldin and Kapner, 2013) and safety breakdowns

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on the Deepwater Horizon oil drilling rig that sent BP into the “worst crisis in its 102-year history” (Chazan, 2010, p. 1), have also illustrated the supply chain level impacts of worker safety that can not only affect material flow but damage reputations as well.

This paper addresses these issues by considering the impact of early supplier engagement on the key social sustainability issue of worker safety. Using the context of the construction industry, this paper first describes the adversarial nature of stakeholders in the supply chain when it comes to the social component of the triple bottom line, even as supply chain literature in areas such as total cost of ownership and sustainability have illustrated the long-term benefits of collaboration and a lifecycle mentality. Based on a sample of 22 case studies, the evolution of what factors are driving decision-making over the lifecycle of a project is explored, including the benefits of considering social sustainability factors earlier in the supply chain and the extent to which engaging key suppliers earlier in the sourcing process can have benefits in this regard. Discussion then centers around an important issue for sourcing managers that was identified through analysis of the qualitative data, which is that the engagement of suppliers on these issues does not always align with previous procurement literature that promotes early engagement primarily on strategic purchases. Instead the cases reveal an interesting behavior by organizations in the sample that aligns with recent research by Paggell et al. (2010), who found organizations realized positive environmental sustainability outcomes through stronger, more strategic relationships with what have been traditionally categorized as commoditized suppliers.

2. Sustainable supply management in the construction supply chain

The emphasis on sustainability in modern supply chain management stems from the concept of interdependence, which drives firms to understand the requirements of stakeholders in their network in order to succeed long term (Savitz, 2013). This includes not only profitability needs of the organization and its investors, but also of the environment and people impacted by the operations of the organization (Elkington, 1999). The interdependence between the three can be seen through the lens of construction worker safety, as the societal impacts of an accident or fatality are easy to recognize in addition to the financial effects on the organization (Feng et al., 2015; López-Alonso et al., 2013). Issues such as these illustrate how sustainability initiatives can be “a source of opportunity, innovation, and competitive advantage”, but the implementation of these initiatives are “so fragmented and so disconnected from business and strategy as to obscure many of the greatest opportunities for companies to benefit society” (Porter and Kramer, 2006, p. 2).

The type of fragmentation in the supply chain mentioned above has been extensively studied, as aligning multiple firms with diverse objectives can be complex. In fact, research has shown that in terms of barriers to a sustainable supply chain that there are as many barriers external to the organization as internal (Walker

et al., 2008). One of the external interactions that has been shown to have an important impact on sustainable outcomes is the purchasing and supplier relationship. Authors such as Zsidisin and Siferd (2001), Bowen et al. (2001) and Foerstl et al. (2010) have all discussed the operational and reputational consequences of purchasing and supplier integration on a successful sustainability strategy. These articles lay a foundation of procurement as a boundary spanning function in organizations that holds a key to successful sustainability outcomes through the proactive engagement of suppliers in the lifecycle.

One of the proactive strategies an organization can employ to improve performance toward its sustainability goals is engaging key suppliers earlier in the design process. The positive impact of supplier engagement in the design phase on financial performance has been discussed extensively in the new product development literature (Petersen et al., 2005; Primo and Amundson, 2002; Ragatz et al., 1997) and sustainability specifically (Walton et al., 1998; Zhang et al., 1997), as suppliers often have the detailed product and/or process knowledge that is a critical resource for a successful implementation phase. In fact, focused concepts such as design for the environment (Fitzgerald et al., 2005, 2007; Zhang et al., 1997) and design for safety (Akladios et al., 1998; Gambatese et al., 1997; Karsh, 2004) have emerged detailing the benefits of considering these specific factors earlier in the design lifecycle. While the potential benefits have been discussed, the implementation of these types of sustainability issues as a decision influence during design is many times still a primarily internal activity with low involvement from outside resources (Van Hoek, 1999) due to the difficulties in obtaining this type of data (Fitzgerald et al., 2005) and the perceived cost of incentivizing suppliers to collaborate on these issues (Min and Galle, 1997; Rao and Holt, 2005). Sustainable supply management however necessitates organizations move away from these types of behaviors and consider influences beyond those normally considered in purely operational decisions (Bai and Sarkis, 2010).

Table 1 gives an overview of these issues specific to the construction industry. As the table illustrates, the construction industry is an industry in which collaboration in the supply chain has been problematic outside of individual projects (Gadde and Dubois, 2010). This has led to fragmentation and misalignment among organizations, and has been attributed to complex relationships and a “one-off” nature in which firms move from project to project, have low collaboration, and are seen as only responsible for their specific piece of the venture (Blayse and Manley, 2004). This type of environment presents an opportunity to research issues in how the fragmented supply network in “project-based, service-enhanced” supply chains such as construction can be better managed to improve sustainable outcomes by focusing on lifecycle influences of project performance rather than price-focused demand–supply interactions (Gann and Salter, 2000; Kamann et al., 2006). Lifecycle influences tend to be undervalued and addressed in the latter stages of the project lifecycle, even as research has shown the benefits of incorporating lifecycle-based factors earlier in the procurement process through early supplier engagement (Eriksson and Westerberg, 2011; Swan and

Table 1
Key issues affecting sustainable supply management in the construction industry.

Key issue	Citations
Low collaboration between firms in the supply chain	Blayse and Manley (2004), Gadde and Dubois (2010), Kent and Becerik-Gerber (2010)
Price-focused interactions between firms	Gann and Salter (2000), Kamann et al. (2006), Zimina et al. (2012)
Key construction suppliers viewed as interchangeable commodities	Akintoye et al. (2000), Khalfan et al. (2001)
Worker safety left to implementation stage	Behm (2005), Gambatese et al. (2005), Gambatese et al. (1997), Hinze and Wiegand (1992), Huang and Hinze (2006), Lingard et al. (2014)

Khalfan, 2007).

One reason attributed to the focus on price in the construction industry is that most relationships between key stakeholders in the construction industry, such as owners, designers, contractors, and subcontractors, are based on purely contractual terms (Khalfan et al., 2001) in which suppliers are viewed as commodities that can be dispensed of as needed (Akintoye et al., 2000). This fragmentation can have an adverse effect on key performance outcomes, as literature has shown that a large percentage (50–70%) of costs, environmental impacts, and ability to control safety outcomes can be linked to decisions made during the design phase (Asiedu and Gu, 1998; Behm, 2005). In the construction industry however, sustainability issues in the social domain that pertain to worker safety are often left to the implementation stage for the contractor and subcontractors to address (Behm, 2005; Hinze and Wiegand, 1992; Huang and Hinze, 2006), even though research has shown that they are more effectively controlled during the planning, design, and procurement stages of a project (Gambatese et al., 2005).

Based on the factors described above, the construction industry presents an attractive setting to study the effect of early supplier engagement on sustainable outcomes. While this topic has been addressed, much of the work in sustainable supply management has been concerned with environmental performance (Huq et al., 2014). Therefore, social sustainability issues such as supplier human rights actions, labor conditions and worker safety, codes of practices and social auditing, supplier compliance with child labor laws, and the delivery of social equity through sourcing from diverse suppliers in terms of gender, size, ethnicity and avoidance of conflicts of interest (Awaisheh and Klassen, 2010; Carter and Jennings, 2004; Drumwright, 1994; Handfield and Baumer, 2006; Hughes et al., 2007; Maignan et al., 2002; Worthington et al., 2008) represent an opportunity to investigate the impact of early supplier engagement on these factors. The construction industry is also an appealing opportunity in this regard, as the common social sustainability issue of worker safety is an important topic in the construction industry. Worker safety has been empirically shown to be “vital to construction supply chain processes” (Edum-Fotwe et al., 2001, p. 161). In addition, construction projects are “information-based supply chains” in which the quality and timing of specialized information transactions amongst key actors is a critical success factor of worker safety performance (Edum-Fotwe et al., 2001; McCreddie and Rice, 1999). Safety as a proxy for sustainable outcomes also presents an opportunity to directly measure these benefits, as measuring safety performance is straightforward using established mechanisms for assessing effective safety controls (Manuele, 2003).

This leads to three fundamental research questions that are addressed in this paper, which are

1. What is the performance impact of incorporating social sustainability factors, as measured by worker safety outcomes, as a decision factor earlier in the construction supply chain process?
2. At what stage of the construction supply chain is supplier engagement an effective strategy for incorporation of social sustainability decision factors?
3. What are the specific types of sourcing decisions in which early supplier engagement should be used to improve social sustainability outcomes?

3. Methods

As stated, the fundamental questions in this paper revolve around the performance impacts of incorporating social sustainability factors

earlier in the supply chain process, and if supplier engagement on these issues is an effective strategy for early incorporation of these factors. This section describes the process used to collect and analyze data surrounding this issue using a sample of 22 case studies. The research design and sample selection are first described and are followed by how the qualitative data was reduced and categorized such that comparisons could be made between cases.

Case study research is an appropriate medium for these goals, as it allows a rich understanding of the dynamics of a setting by providing a description of these dynamics and testing theory through the collection of both qualitative and quantitative data (Eisenhardt, 1989). Using safety as a lens to study the dynamic of early supplier integration on sustainable outcomes opens the opportunity to collect quantitative data on safety performance, and therefore statistically test potential factors that impact this performance. Thus, these research goals align with a mixed methods design given the need for both quantitative methods for testing and validating theories using a hypothesis testing approach as well as qualitative methods such as case studies that lend themselves to exploring how and why phenomena occur (Johnson and Onwuegbuzie, 2004; Yin, 2006). Overall, the research design was based on a seven stage process developed by Onwuegbuzie and Teddlie (2003) for mixed methods research. The framework developed by Yin (2013) for case study research was used to guide data collection and analysis of qualitative data, and was supplemented by a mixed methods research design process developed by Tashakkori and Teddlie (1998) for converting qualitative data obtained through case studies into quantitative data through the utilization of numerical codes. Fig. 1 gives an overview of the research design and process used for data collection and categorization.

3.1. Sample selection and unit of analysis

Following the framework developed by Yin (2013), a consistent scope for each case is an integral component of developing a case based research design. Each case must be bounded to allow for efficient data collection while completely answering the research questions. Each case was bounded at the supply chain level, because as in most industries there are multiple supply chains occurring on a construction project (e.g. the foundation, external structure, internal systems, etc.) that are distinct from other supply chains on the project and constrain themselves sufficiently.

The number of cases in the sample also had to be determined as part of the research design. The construction industry is characterized by multiple procurement methods that impact supplier relationships (design–bid–build, design–build, collaborative, accelerated) as well as multiple industry segments that bring distinctive supply chain issues and characteristics (residential, commercial, industrial, heavy engineering), which made sampling size and case identification an important issue. A group of five construction industry experts from academia and industry were contacted to discuss and determine if these categorizations covered the depth of breadth of the construction industry. They were also used to develop specific definitions of each procurement method and industry segment (e.g. residential is three story and below detached buildings and does not include high-rise condominiums) to ensure consistency during the data collection process.

A case was desired for_ENREF_87 each combination of procurement method and industry segment (resulting in at least 16 cases) in order to control the sample being biased by traits specific to a given procurement method or industry segment. This design also allowed the “saturation” level described by Yin (2013) to be achieved. This “saturation” maximized variation in the sample, thus increasing the external validity of the study, and was feasible given the long length of the grant supporting the research (five years). Sixteen diverse cases also provided multiple sources of evidence to support a high

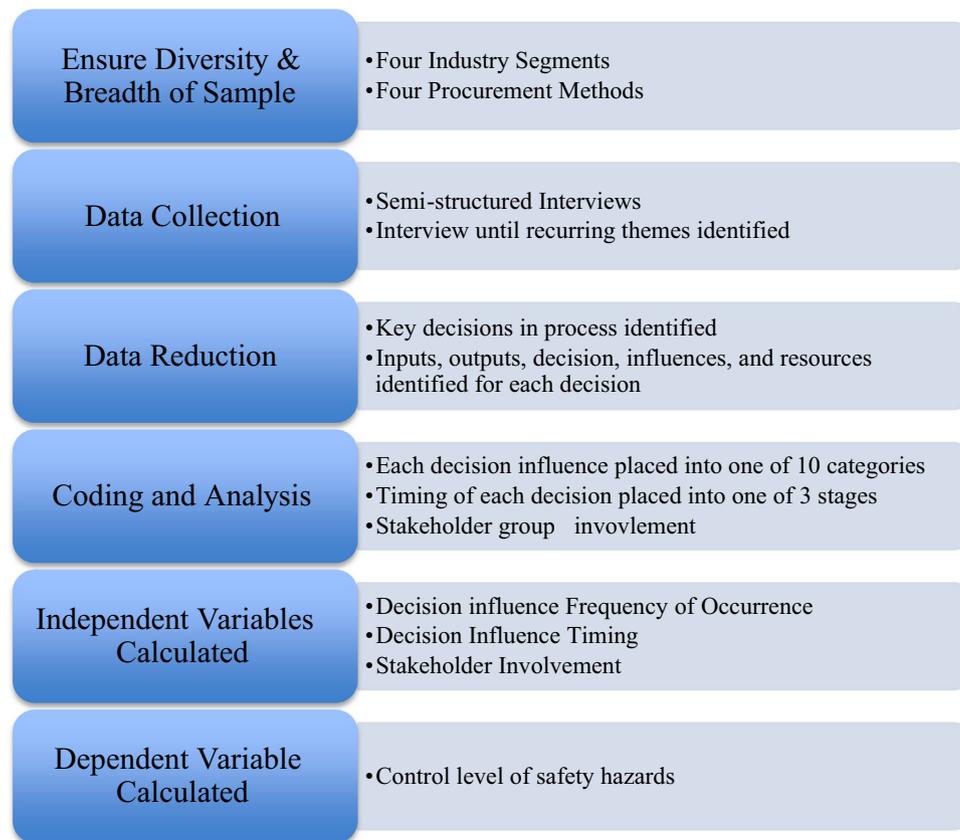


Fig. 1. The research design process.

level of construct validity, as well as give a large enough sample to provide sufficient internal validity for testing existing theory as outlined by Yin (2013).

As discussed, strict definitions were first established for each procurement method and industry segment using relevant literature and expert knowledge. Next, cases were selected using a purposeful sampling with maximum variation approach by acquiring access to cases through existing contacts in the construction industry. These contacts assisted in identifying potential projects that fit the definition for a specific combination of procurement method and industry segment. Following previous qualitative research guidelines, care was also taken to find information-rich cases on the research issues in question that were diverse enough to identify common patterns (Creswell, 2006; Patton, 2005). An effort was also made to select cases in which no organization was involved in more than one project in the sample, as to not bias the data toward any single organization's internal processes and ensure maximum diversity. The resulting cases that were included in the study are detailed in Appendix A. A case for the collaborative/residential combination could not be found and one project was used for two combinations (coal plant upgrade). The resulting sample size was 14 projects and 22 cases.

3.2. Interview protocol and data collection

The research design for collecting the qualitative data followed well-established literature in case study research (Creswell, 2006; Yin, 2013) and aligned with existing case-based research in sustainable supply chain management (Barratt and Oke, 2007; Matos and Hall, 2007; Pagell and Wu, 2009; Walton et al., 1998). The first step for each case was setting up a phone call with someone that had a good overall knowledge of the project in order to identify the supply chain(s) to focus on during data collection. This was

usually the main contractor's project manager, as the construction companies were usually the point of contact and this position has a good knowledge of the overall project. A semi-structured interview was then conducted in which the contact was asked to give an overview of the project and then to describe parts of the project in which sustainability issues such as safety were a part of the decision-making process. These questions were a starting point that allowed the researchers the flexibility to understand if the respective piece of the project was a good prospect for the research. A site visit was then set up if possible, which served the dual purpose of giving context to the project in question and conducting face-to-face interviews on-site with as many personnel as possible. These interviews were also semi-structured, and the respondent was asked to give an overview of the main decisions in the supply chain, options that were considered for each decision, and why the ultimate option was chosen over others. Follow-up questions were asked for each decision, including the main stakeholders involved in each decision and their respective decision-making influence/power, but the semi-structured nature protected against leading the subject based on data obtained from prior interviews. Contacts for other stakeholders in the supply chain such as owners, designers, and other key suppliers were obtained while on-site, and contact was made and phone interviews conducted as soon as possible after the site visit. Stakeholders were identified and interviewed until saturation occurred as identified through recurring themes in the interviews (Yin, 2013). In total, approximately 120 interviews were conducted across the 22 cases (some stakeholders were interviewed for multiple cases where appropriate).

3.3. Data reduction mechanism

Developing a common and consistent structure for reducing and

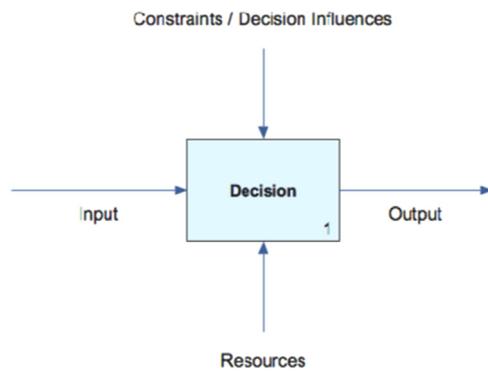


Fig. 2. IDEF-0 Format.

simplifying a complex decision process down to a series of decisions that can be meaningfully compared across projects is the first stage in the mixed methods process outlined by [Onwuegbuzie and Teddlie \(2003\)](#). The Integrated Definition Level Zero (IDEF-0) methodology developed by the United States Air Force for systems modeling was evaluated for this task based on an extensive history of using it to model and describe activities at various levels of detail in a common format ([Kusiak, 2002](#)). This methodology was ultimately chosen because it is “designed to model the decisions, actions, and activities of an organization or system” in a way that can be compared in a straightforward manner ([Knowledge Based Systems, 2010](#), p. 1), which aligns well with the stated research goals. Another step in the process outlined by [Onwuegbuzie and Teddlie \(2003\)](#) is developing a visual mechanism to display and compare data, and the IDEF-0 also represented a convenient format to accomplish this step. As shown in [Fig. 2](#), the format for each key decision in the supply chain is the documentation of inputs, outputs, key influences, and resources used to make those decisions.

3.4. Coding and analysis

3.4.1. Data transformation

The IDEF-0 format for each key decision in each case was built into a process diagram similar to the example in Appendix B. The research team built the diagram for each case as a group to increase reliability, and then the diagram was sent to project stakeholders for feedback until agreement was reached that it was a valid representation of the key decisions in the supply chain and that the listed decision influences were accurate. The information in each diagram was then categorized, as described below, by the research team so that relevant statistical analysis could be performed.

3.4.2. Coding schemes

Converting qualitative data into numerical codes that can be analyzed statistically is an integral step of mixed methods research ([Tashakkori and Teddlie, 1998](#)). Key influences affecting each decision were captured during the data collection phase and documented on the diagrams as a “constraint” in the IDEF-0 methodology. Each key influence was then categorized using classifications developed by [Sink et al. \(1989\)](#) for measuring organizational performance and used by [Kleiner \(1997\)](#) for measuring and evaluating information management performance. This scheme allowed a more direct comparison between projects, and the categories with a brief description for each are below.

1. Efficiency – resource utilization and meeting project schedule objectives (project schedule).
2. Effectiveness – meeting project or organizational objectives or scope (e.g. esthetics, layout, ability to meet other design

requirements).

3. Productivity – maximizing output/input and includes people, equipment, and other resources (worker productivity policies).
4. Quality- broadly defined to include factors such as materials and construction output (e.g. durability, constructability, product quality).
5. OSH-worker well-being (e.g. worker safety).
6. Innovation – developing new process, procedures, and ideas (e.g. using new construction method to replace current ones).
7. Funding – includes meeting budget objectives and cost constraints (e.g. budget considerations, material cost, labor cost).
8. Regulatory – includes legal and external agencies affecting project (e.g. environmental agencies such as EPA).
9. Policy – organizational and project level issues (e.g. organizational sustainability policy).
10. Other stakeholders – direct personnel involved with project or personnel that are absent from the project that affect decision-making process (e.g. community groups or non-governmental organizations).

The timing of when social sustainability issues were considered in the lifecycle was also an important research variable. Each decision was classified into the planning, design and procurement, or construction stage ([Lingard et al., 2009](#)) so that the timing of each decision and its associated constraints could be quantified.

Coding these variables using these schemes allowed a percentage to be calculated of how often each decision influence was present within each stage. This allowed a convenient manner in which to test not only if different influences varied in their strength over the lifecycle of a project, but more importantly whether there were differences in performance outcomes when social sustainability was an influence earlier in the project lifecycle. A more detailed description of the process used to develop this data is also described in Appendix B.

The ultimate outcome of a safe working environment should be the lack of occurrence of near incidents, accidents, or fatalities. Obtaining this measurement for each of the projects, while feasible, was problematic because data collection occurred at different stages for each project and many of the projects were not complete when data collection ended. Also, data was collected at the feature of work (supply chain) level, and the industry collects data at the project level. It would thus be misleading to report on project level outcomes when the true concern of this research is focused on safety outcomes just for the feature of work that is the focus of the case.

The hazards specific to each feature of work could however be identified during data collection. For safety outcomes, there is an established hierarchy of controls in which higher level “technological” controls such as eliminating a hazard, substitution of a hazard for a lesser hazard, and the implementation of engineering controls have been shown to be more effective than “behavioral” controls defined as administrative processes (safety rules and procedures, jobsite hazard analysis, etc.) and personal protective equipment (PPE) ([Manuele, 2003](#)). The potential hazards that were identified for each case from the interview data were coded from one to five (1=PPE, 5=elimination) by the research team as to how each was controlled as classified by the hierarchy of control. This is an effective manner to measure safety outcomes, as it is proactive in nature and allows the ability to measure the control of the actual feature of work’s supply chain in question and not have to rely on reactive project-level safety outcomes such as lost time rate that can be confounded by other influences.

Stakeholder involvement was also collected during the interview process for each stage of the supply chain in order to determine if it had an effect on safety outcomes. Each interviewee was asked to list the groups or firms they interacted with during

each stage of the project (planning, design and procurement, implementation), which allowed a matrix to be built of stakeholders present in the decision-making process during each stage. This data was developed by the research team and then sent to the interviewees for corroboration and feedback to update the matrix and support reliability of the data collection process. This data allowed for analysis of whether involvement by individual stakeholders at different stages of the lifecycle impacts the outcome variable.

4. Results

4.1. Evolution of decision Influences across supply chain

The data collection framework described above allows for some interesting insights into decision influences over the lifecycle of the supply chain. Table 2 shows how often a given decision category was present as an influence within each stage for the 14 projects and 22 cases that comprised the sample for this research.

This data was analyzed for differences between categories within each stage using a matched pairs Analysis of Variance (ANOVA) procedure as well as for each category between each stage using a student's *t* testing procedure. Differences between categories were tested for each stage using a Bonferroni adjusted overall level of significance of 0.0022 obtained by dividing the overall level of confidence (0.10) by the 45 combinations that were possible between categories. The results are summarized in Fig. 2, and demonstrate how categories such as funding (category 7) are statistically more prevalent in the earlier stages of the lifecycle than safety, innovation, regulatory issues, policy, and other stakeholder influences. These factors appear to be the ones that are guiding decision-making early in the lifecycle, with little attention given to categories not directly related to profitability.

When analyzing for each category between stages, the results corroborate that direct factors such as meeting schedule requirements, funding, and project objectives (effectiveness and quality) are either constant or more frequent in the earlier stages of a project. Other factors difficult to quantify in terms of cost, such as safety, worker productivity, and meeting regulatory requirements (including environmental), exhibit the opposite behavior and tend to increase over the lifecycle. These factors must be considered at some point in order to meet project objectives, but data indicate that they are generally left to the later stages before they are addressed (when the ability to impact them is much lower).

The overall results are summarized in Fig. 3, and illustrate the degree to which “direct” influences such as budget (funding category) and meeting schedule requirements (efficiency category)

Table 2
Percentage of decision influence prevalence by project stage.

Decision influence	Project stage		
	Planning (%)	Design and procurement (%)	Implementation (%)
1. Efficiency	41	86	73
2. Effectiveness	91	73	27
3. Productivity	0	45	77
4. Quality	45	73	45
5. Safety	9	41	91
6. Innovation	14	0	0
7. Funding	86	91	77
8. Regulatory	27	14	50
9. Policy	23	41	9
10. Other Stakeholders	23	14	9

drive decisions in the early stages of a construction project versus “indirect” factors such as safety and productivity. These data are important for understanding what is driving decisions over the project lifecycle, but an understanding is still required if shifting this behavior leads to better outcomes. The following analysis tests the hypothesis of whether considering social sustainability factors earlier in the lifecycle has a relationship with its performance.

4.2. Effect of early supplier engagement on social sustainability outcomes

Among the case study projects, there was a subset of projects where safety was a decision influence in the pre-implementation stages of a project. When safety was a decision influence during the design and procurement stage (9 cases) there does appear to be a higher level of control for potential hazards per project. Using the coding described earlier, the average control was 2.81 (out of 5) when safety was a consideration in the design and procurement stage versus 2.35 when it was not a consideration in the design and procurement stage. As Table 3 displays, there is a statistically significant difference between these two levels with a level of significance of 0.0012. Using safety as a proxy for social sustainability factors, this analysis quantitatively illustrates the positive performance impact of earlier consideration of these factors in the supply chain. Understanding strategies to effectively accomplish shifting this consideration to earlier in the lifecycle is the next key step that must be analyzed.

The moderating effect of involving suppliers earlier in the procurement process was tested to determine if it had an effect on sustainability outcomes. The supplier that was tested for each supply chain was the key subcontractor primarily responsible for implementation of the existing design, as the construction manager is generally a member of the core organizational unit early in the lifecycle along with the designer and owner and not considered a supplier. The data show that there is in fact a positive performance impact of early supplier involvement, as the cases with supplier involvement in the design and procurement stages (12 cases) had an average outcome of 2.69 versus 2.36 in the ones (10 cases) in which there was no early supplier involvement with a level of significance of 0.0270. The results are shown in Table 4, and indicate that early involvement by key suppliers can positively affect social sustainability outcomes. Understanding when to facilitate this involvement is a practical issue that must be determined, as managers need to know when this strategy is the most effective use of time and resources.

4.3. Qualitative analysis of cases with early supplier engagement

The results indicate a positive effect of supplier engagement early in the procurement process as a strategy to improve social sustainability outcomes. The qualitative data collected was analyzed to determine if there were patterns or other relationships in the cases with early supplier involvement. Understanding these patterns would be valuable from a practical standpoint for determining conditions when this type of involvement would be best utilized to improve outcomes. Traditionally, the sourcing literature would indicate that this type of early supplier involvement would be best suited for strategic goods and services (Kraljic, 1983). Interestingly, in the cases in the sample most of the examples of early supplier involvement aligned with supply issues that would generally be considered leverage or commodity purchases.

This result interestingly aligns with recent research by Pagell et al. (2010) that found that a group of exemplars in sustainable (environmental) supply chain management were routinely buying traditional leverage products and services in a manner more aligned with strategic purchases. This research attributed this behavior to

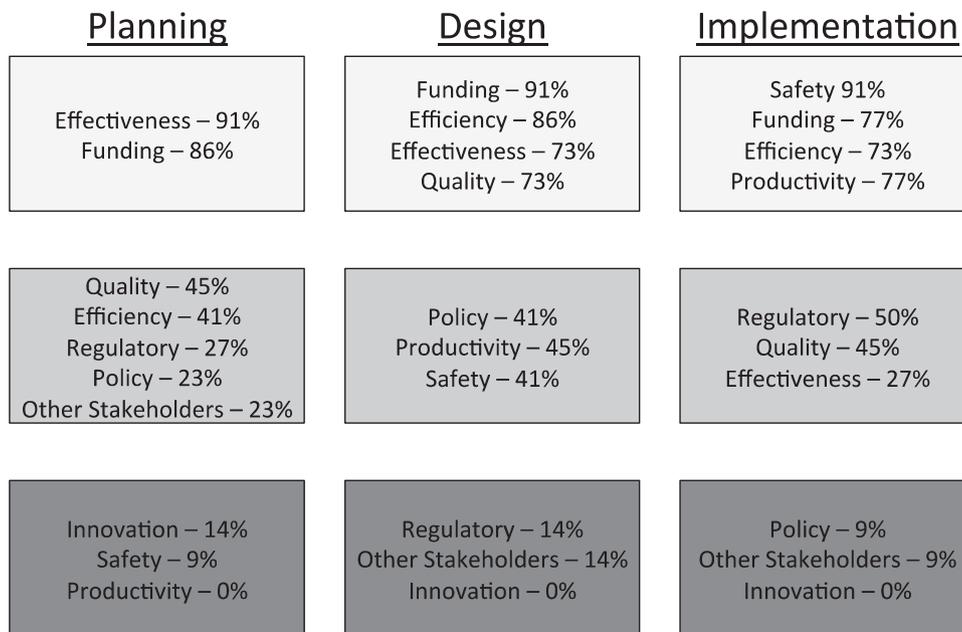


Fig. 3. Differences within and between stages for decision influence categories.

Table 3
ANOVA of effect of safety as an influence during design and procurement on safety outcomes.

Safety influence in design stage	Count	Hazard control average	P-value
No	13	2.35	0.0012*
Yes	9	2.81	

* signifies that the p-value is statistically significant at a 0.05 level of significance.

Table 4
ANOVA of early supplier engagement on safety outcomes.

Early engagement of subcontractor	Count	Hazard control average	P-value
No	10	2.36	0.0270*
Yes	12	2.69	

* signifies that the p-value is statistically significant at a 0.05 level of significance.

shifting stakeholder expectations, and propositioned that competitive advantages may not only come from “increased monetary profits but rather from an increased ability to extract above-average rents (based on a resource-based view) on social and/or

environmental performance” (Pagell et al., 2010, p. 67). This opens the door to determine if social factors are impacting behavior in a similar manner to environmental factors.

One of the key issues discovered when analyzing the 12 cases in this sample with early supplier involvement is that, while a majority of the purchases were commodities by nature, the large volume itself actually created a significant impact on key project drivers that shifted them to be treated more strategically. For example, one of the cases was the construction of a new \$385 million (USD) hospital. The interior systems (electric, HVAC, plumbing, etc.) and interior wall suppliers were brought in early to pre-fabricate all of the walls in a leased warehouse so that once on-site all that needed completed was installation. There were many similar, capable contractors in the market that could complete this work, and this would clearly be a traditional leverage purchase due to the large volume of walls and interior systems in the hospital. What the purchasing organization noted is that this pre-fabrication process minimized the time required on-site by these suppliers by performing their work in parallel instead of sequentially. The social impact in terms of safety is related, as even though not necessarily risky by nature, the sheer volume of these assemblies created a large opportunity for incidents based on contact alone. Table 5 gives an overview of all 12 of these cases, and the primary reason attributed by interviewees for why the early engagement

Table 5
Cases with early supplier engagement.

Case	Type of purchase	Reason for early supplier involvement
Football stadium foundation system	Strategic	Proximity to adjacent structures made foundation important feature
Psychiatric hospital precast panels	Leverage	Volume of panels on exterior
Psychiatric hospital roof structure barricades	Leverage	Volume of barricades
Wastewater tank pre-stressed concrete tank	Strategic	Construction of tank was key component of project
Server farm gas fire suppression system	Bottleneck	Few suppliers and specialized item
University cafeteria steel superstructure	Strategic	Critical driver of project schedule and cost
Chemical plant steel tower	Leverage	Coordination required to minimize construction time at plant
New interstate maintenance of traffic	Leverage	Volume of interfaces with existing roadways
Hospital steel superstructure	Strategic	Critical driver of project schedule and cost
Hospital interior walls and systems	Leverage	Volume of interior walls, mechanical, and electrical in building
Coal plant upgrade utility installation	Leverage	Volume of new utilities required to serve upgrade
Coal plant upgrade duct system	Leverage	Volume of duct and associated supports required

was initiated (similar to the example above).

The type of relationship described above was found in multiple cases, as of the 12 cases with early supplier involvement six of those were leverage purchases in which the supplier was engaged early due to the impact of large volume on economic and noneconomic outcomes. Minimizing the time required on-site not only had a positive schedule impact in all cases (a key profitability driver), but also minimized risk in terms of opportunities for environmental, health, and safety issues. Expanded risks outside of economic factors were cited by Pagell et al. (2010) as a key driver of expanding the leverage category in Kraljic's matrix into three categories (true commodities, transitional commodities, and strategic commodities). It is in the category of strategic commodities in which the results from this research support the findings of Pagell et al. (2010) in which increased investment in a traditional commoditized supplier through early engagement led to increased performance on multiple dimensions of the triple bottom line, as all of the examples of early engagement led to documented social benefits in terms of worker safety. This finding has both theoretical and managerial implications, as it does not align with traditional sourcing literature on supplier segmentation.

5. Discussion

5.1. Theoretical implications

There is a large collection of sourcing literature based on a portfolio approach first introduced by Kraljic (1983) that states that the large volume being procured in the leverage category gives purchasing organizations buying power over suppliers that they should exploit to drive down prices (Caniëls and Gelderman, 2005). Recently there has been work such as Gelderman and Van Weele (2003) that suggests that leverage suppliers should be transitioned into more strategic partnerships when technical capabilities allow them to add to the competitive advantage of the firm. Pagell et al. (2010) cited adding value as a reason that environmental sustainability was driving more strategic partnerships with traditional leverage suppliers, as many suppliers possess specialized knowledge necessary that can increase performance from a sustainability perspective. The results of this study align with these findings, and suggest that these shifting strategies have positive impacts from a social sustainability perspective in addition to the environmental performance aspect discussed by Pagell et al. (2010). This type of behavior should be expected to increase as a triple bottom line mentality becomes more and more common for modern organizations.

The positive results of early supplier involvement on sustainability outcomes have been discussed in literature (Ageron et al., 2012; Hollos et al., 2012; Pujari, 2006), but this research not only aligns with those survey and literature based studies but also directly measures those benefits on a critical triple bottom line factor in a supply chain. Results such as these should further push literature to adapt traditional purchasing portfolios and related strategies for managing different supplier segments to the changing dynamics of the economy. Price-based relationships are no longer always appropriate for commoditized products and services, as it disrupts the ability to introduce innovative supply chain management strategies that focus on social and environmental issues (Bai and Sarkis, 2010). Understanding how sustainability is changing stakeholder management was cited by Hoejmose and Adrien-Kirby (2012) as a key research need in sustainable supply chain management, and this work addresses that need and provides further evidence of how factors outside of financial outcomes are shifting sourcing strategies in industry.

5.2. Practical implications

As non-financial factors become more important indicators of performance, organizations must reassess strategies that have been used to manage the supply chain. In a recent international survey of 28,000 respondents, Nielsen found that two thirds (66%) of consumers around the world say they prefer to buy products and services from companies that have implemented programs to give back to society (The Nielsen Company, 2012). It is not only customers that are demanding sustainable business practices, as “workers say they want a clear corporate conscience—so much so that they'd take a pay cut to work at a company that makes socially responsible choices like promoting employee safety and preventing child labor, according to a new Bain & Co. study of nearly 750 workers” (Kwoh, 2012, p. 1). In fact, the same article stated that two-thirds of respondents said they cared more about sustainability at the time of the survey than they did just three years ago. Data such as this underlies the growing importance of companies choosing strategies that best align with these new benchmarks of success.

Organizations would not typically consider a supplier such as an electrician or plumber as one that adds strategic value and thus needs to be treated accordingly. The findings of this research suggest that in certain situations this paradigm is not true, and “commoditized” suppliers can in fact add strategic value. The early engagement of these suppliers can be a strategy to increase performance in areas of sustainability, but recognizing when this strategy is most appropriate is paramount for successful outcomes. In this sample, instances in which the high volume of the purchase also increased the potential for a safety incident was the condition in which early supplier engagement was reported to have the most benefits. No early involvement makes sense from a strictly financial standpoint, as high volumes alone lead to economies of scale that can drive down costs for the supplier and ultimately the purchasing organization without a high degree of integration. The large volume however also increases potential exposure for sustainability factors such as environmental impact and safety, and thus some strategy should be implemented to account for these impacts. The focal organization might not possess the internal knowledge to reduce this exposure, and therefore early integration of suppliers who do possess this knowledge becomes an effective strategy. Organizations thus need to assess the potential social sustainability impacts of potential purchases early in the life-cycle, and integrate relevant suppliers early in the design lifecycle if the impacts are deemed important enough.

6. Conclusions and future research

This manuscript presents new evidence of the impact of early supplier engagement on an important triple bottom line criterion. The construction industry was an advantageous setting to explore these relationships, as the fragmented nature and reliance on safety as a key performance driver allowed data to be collected on a triple bottom line aspect with a well-documented means of measuring performance. Future research can test the relationships found in more traditional aspects such as environmental performance, but this research illustrates the potential benefits outside of economic outcomes that can be attained through supplier engagement in non-strategic purchases. It might seem counter-intuitive in practice to invest more heavily in relationships with these types of suppliers, but changing demands have opened the door to engage these suppliers to increase performance in multiple areas. Volume seemed to be the key driver of making traditional commoditized purchases more strategic in nature in the project-based supply chains analyzed in this research, as the high volume increased risk for not only cost and schedule but for

sustainability outcomes as well.

It is important that this outcome aligns with other research on purchasing strategies for improving non-economic triple bottom line outcomes (Pagell et al., 2010), as these demands are relatively recent and understanding how purchasing portfolios should differ moving forward will continue to be a key research area as non-financial criteria become more important indicators of success. While this research supports the strategic commodity category identified by Pagell et al. (2010) as the segment in which much of this early integration is occurring, there is still an opportunity to further refine this category to identify specific attributes that make

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Table A.1
Demographics and feature of work description by case study.

Project	Procurement method/industry segment	Feature of work (case)	Descriptions
Football stadium	Accelerated/commercial	Foundation system Steel superstructure	Excavation & installation of micro-pile foundation system adjacent to existing parking garage and around existing utilities Demolition of existing stands and steel erection of new seating structures and press box
Psychiatric hospital	Design-build/commercial	Exterior pre-cast concrete panels Roof structure and barricades	Lift and place of pre-cast concrete panels on exterior and attachment to structural steel Installation of roof membrane and construction of permanent roof barricades around HVAC
Habitat for Humanity House construction	Accelerated/residential	Exterior structures (basement, exterior walls, roof)	Pre-fabrication and construction of exterior & interior walls and roof structure
Wastewater tank	Design-bid-build/industrial	Pre-stressed concrete tank Sewer trunk line across creek	Excavation and shoring of tank location and construction of pre-stressed concrete tank Installation of sewer trunk line across creek from barge using divers
Design-build house	Design-build/residential	Exterior structures (basement, exterior walls, roof)	Site excavation, installation of pre-formed concrete basement, and construction of exterior walls and roof structure
Server farm	Design-build/industrial	Demolition of existing structure Gas fire suppression system	Demolition of existing one-story structure and separation of waste and recyclables for LEEDS Installation of tanks, actuator valves, and distribution pipe for gas fire suppression system
University cafeteria	Design-bid-build/commercial	Foundation system Steel superstructure	Excavation of site and construction and backfill of front retaining wall Delivery of steel beams and lift and place of steel structure around two adjacent buildings
Chemical plant upgrade	Accelerated/industrial	Steel structure for new equipment	Pre-fabrication of steel structure for new equipment and tie-in to existing plant infrastructure
Road reconstruction	Design-bid-build/heavy engineering	Maintenance of traffic Utility replacement	Maintenance of traffic plan during reconstruction of 6-lane highway and re-pavement of adjacent side streets Excavation and condemnation of existing utilities and installation of new utilities
Bridge reconstruction	Accelerated/heavy engineering	Maintenance of traffic	Maintenance of traffic during removal of existing asphalt and installation of new asphalt on one lane of 4-lane bridge
New interstate	Collaborative/heavy engineering	Maintenance of traffic	Maintenance of traffic on haul roads, temporary bridges, and public roads
Hospital	Collaborative/commercial	Steel superstructure Interior walls and systems	Lift and place of steel beams for structure Pre-fabrication of internal walls and installation of electrical and mechanical systems in building
Design-bid-build house	Design-bid-build/residential	Exterior structures (basement, exterior walls, roof)	Site excavation, installation of pre-formed concrete basement, and construction of exterior walls and roof structure
Coal plant upgrade	Collaborative/heavy engineering Collaborative/industrial	Utility installation Steel structure for duct system	Excavation for and installation of new utilities for recycling water for new air scrubbers Assembly and lift and place of steel supports and installation and connection of ducts for new air scrubbers

this strategy successful. There were other items and services in the sample that could have been placed in this category, but early integration of suppliers was not chosen for various reasons. Understanding the consequences of not utilizing early integration or attributes of why these purchases were not suitable for the strategy is an opportunity for future research. Overall, this research presents exciting results that challenge existing paradigms of strategies for interacting with leverage suppliers, and there are numerous opportunities moving forward to explore how these relationships can be best utilized to increase overall performance in a triple bottom line environment.

Appendix A. Case study overview

See appendix [Table A.1](#).

Appendix B. IDEF-0 case output

Using the IDEF-0 methodology, a decision process was developed for each case study. [Fig. B.1](#) is an example of an output for one of the cases in the sample. Each decision in the process had key influences that were categorized as a constraint in the IDEF-0 format. These influences were then coded using the scheme

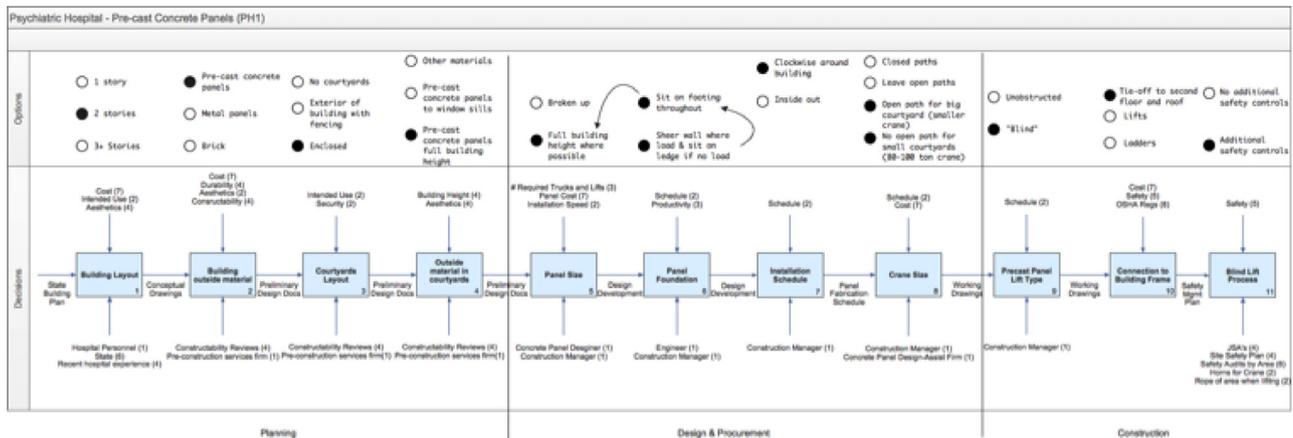


Fig. B.1. Decision process flow chart for sample case.

Table B.1 Decision influence data for Fig. 1.

Planning stage	2. Effectiveness	4. Quality	7. Funding
Design stage	3. Productivity	7. Funding	2. Effectiveness
Implementation stage	2. Effectiveness	5. OSH	7. Funding

described in the body of the paper in order to allow comparison of the strength of types of influences in the supply chain decision process. In order to determine the frequency of different key influences on decision-making, the researcher team assigned each type a binary value of “yes” or “no”, indicating whether the specific influence was considered for at least one decision during the stage in question. Thus every decision the team identified during data collection contained an opportunity for a specific influence to be present in the decision-making process. Each case was individually coded, and then reviewed by the research team and discussed until 100% agreement was reached to ensure a sufficient level of reliability. This process allowed for a frequency to be calculated as a percentage that a given influence was present for a feature of work within a stage. Table B.1 presents these data for the decision map shown in Fig. B.1.

To calculate the overall percentage for the sample, the researchers first counted the number of cases with a value of “yes” for each category within the stage in question. The percentage a given influence category was present within each project stage was then calculated using the following formula:

$$\text{Influence category percentage for stage} = \frac{\text{Total count of "Yes" of category for stage}}{\text{Total number of cases in sample}}$$

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