

Journal of Business Logistics

VOLUME 34, NUMBER 2, 2013

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Print & Online: US\$ 281 (US), US\$281 (Rest of World), €231 (Europe), £199 (UK). Prices are exclusive of tax. Asia-Pacific GST, Canadian GST and European VAT will be applied at the appropriate rates. For more information on current tax rates, please go to www.wileyonlinelibrary.com/tax-vat. The price includes online access to the current and all online back files to January 1st 2009, where available. For other pricing options, including access information and terms and conditions, please visit www.wileyonlinelibrary.com/access.

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Journal of Business Logistics, (Print ISSN: 0735-3766 Online ISSN: 2158-1592) is published quarterly on behalf, The Council of Supply Chain Management Professionals by Wiley Subscription Services, Inc., a Wiley Company, 111 River St., Hoboken, NJ 07030-5774.

Postmaster: Send all address changes to Journal of Business Logistics, Journal Customer Services, John Wiley & Sons Inc., 350 Main St., Malden, MA 02148-5020.

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Printed in the USA by The Sheridan Group

Data Science, Predictive Analytics, and Big Data: A Revolution That Will Transform Supply Chain Design and Management

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We illuminate the myriad of opportunities for research where supply chain management (SCM) intersects with data science, predictive analytics, and big data, collectively referred to as DPB. We show that these terms are not only becoming popular but are also relevant to supply chain research and education. Data science requires both domain knowledge and a broad set of quantitative skills, but there is a dearth of literature on the topic and many questions. We call for research on skills that are needed by SCM data scientists and discuss how such skills and domain knowledge affect the effectiveness of an SCM data scientist. Such knowledge is crucial to develop future supply chain leaders. We propose definitions of data science and predictive analytics as applied to SCM. We examine possible applications of DPB in practice and provide examples of research questions from these applications, as well as examples of research questions employing DPB that stem from management theories. Finally, we propose specific steps interested researchers can take to respond to our call for research on the intersection of SCM and DPB.

Keywords: data science; predictive analytics; big data; logistics; supply chain management; design; collaboration; integration; education

INTRODUCTION

“Big data” is the buzzword of the day. However, more than the typical faddish fuzz, big data carries with it the opportunity to change business model design and day-to-day decision making that accompany emerging data analysis. This growing combination of resources, tools, and applications has deep implications in the field of supply chain management (SCM), presenting a doozy of an opportunity and a challenge to our field. Indeed, more data have been recorded in the past two years than in all of previous human history.¹ Big data are being used to transform medical practice, modernize public policy, and inform business decision making (Mayer-Schönberger and Cukier 2013). Big data have the potential to revolutionize supply chain dynamics.

The growth in the quantity and diversity of data has led to data sets larger than is manageable by the conventional, hands-on management tools. To manage these new and potentially invaluable data sets, new methods of data science and new applications in the form of predictive analytics, have been developed. We will refer to this new confluence of data science, predictive analytics, and big data as DPB.

Data are widely considered to be a driver of better decision making and improved profitability, and this perception has some data to back it up. Based on their large-scale study, McAfee and Brynjolfsson (2012) note, “[t]he more companies characterized themselves as data-driven, the better they performed on objective measures of financial and operational results ... companies in the

top third of their industry in the use of data-driven decision making were on average, 5% more productive and 6% more profitable than their competitors” (p. 64). To make the most of the big-data revolution, supply chain researchers and managers need to understand and embrace DPB’s role and implications for supply chain decision making.

DATA SCIENCE, PREDICTIVE ANALYTICS, AND BIG DATA

There is growing popular, business, and academic attention to DPB. For instance, the October 2012 issue of *Harvard Business Review* contained three articles that are relevant to this editorial: “Big Data: The Management Revolution” (McAfee and Brynjolfsson 2012), “Data Scientist: The Sexiest Job of the 21st Century” (Davenport and Patil 2012), and “Making Advanced Analytics Work for You” (Barton and Court 2012). *MIS Quarterly* had a special issue on business intelligence and the lead article was titled, “Business Intelligence and Analytics: From Big Data to Big Impact” (Chen et al. 2012). There is also a plethora of articles in trade and even lay publications on these topics. There is even a new journal, *Big Data*, which premiered in March 2013.

Over the past few years, we have been trying to understand the DPB’s implications for research and education in business logistics and SCM. We believe that these new tools will transform the way supply chain are designed and managed, presenting a new and significant challenge to logistics and SCM. Meeting this challenge may require changes in foci of research and education. Many traditional approaches will need to be re-imagined. Some standard practices may even be discarded as obsolete in the new data-rich environment. Some may see the possibilities as threats rather than opportunities. Yet DPB and SCM are fundamentally compatible, thus the tremendous value of DPB lies within our grasp.

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¹Source: IBM, <http://www-01.ibm.com/software/data/bigdata/> accessed March 27, 2013.

We want to encourage submission of research on topics related to DPB that is relevant to logistics and SCM. Importantly, because there is a lack of agreement regarding the meanings of these terms, and because there is a dearth of articles on how these terms apply to the logistics and supply chain disciplines, we would like to facilitate the process by suggesting definitions, concepts, and avenues for research.

Data science: Powerful tools made relevant by domain knowledge

Generally, data science is the application of quantitative and qualitative methods to solve relevant problems and predict outcomes. One of the salient revelations of today, with the vast and growing amount of data, is that domain knowledge and analysis cannot be separated. This is another motivation to write this editorial. Research in the area of DPB is needed by researchers with domain knowledge in logistics and SCM. Professor Jeff Stanton of Syracuse University was quoted by Dumbill et al. (2013):

From a teaching perspective, as a faculty member I can teach someone how to do a t-test in 10 min, and I can teach them how to write a Python program in half an hour, but what I cannot teach them very easily is the domain knowledge. In other words, in a given area, if you are from healthcare, what you need to know in order to be effective at analysis is very different than if you are in retail. That underlying domain knowledge, to be able to have a student come up to speed on that is very hard. (p. 22)

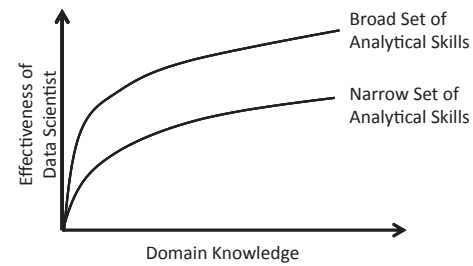
Likewise, Shelly Farnham of Microsoft was quoted by Dumbill et al. (2013):

One of the challenges is that data science is not agnostic of domain. For example, when we are looking for people, interns or full-time people on our team, we definitely look for people who have experience analyzing data, but they also should be deeply engaged with the topic ... I think that the domain knowledge is a very important aspect of what we are looking for. (p. 25)

Thus, academic and applied professionals must have both the analytical skills and the business and management understanding. As Provost and Fawcett (2013) write, "But data science involves much more than just data-mining algorithms. Successful data scientists must be able to view business problems from a data perspective" (p. 52).

Data scientists need deep domain knowledge and a broad set of analytical skills. Developing a broad set of analytical skills requires consistent investments of time. Developing deep domain knowledge requires similar dedication of effort. To that end, typically there is no single individual that can possibly have all of what is needed by a data scientist. If you have someone with lots of domain experience but limited analytical capabilities, it may be difficult to acquire the analytical capabilities. On the other hand, someone with strong analytical capabilities may not be willing to learn the domain or may never have the opportunity to learn the domain. Perhaps, developing analytical capabilities may

Figure 1: Effectiveness, domain knowledge, and breadth of analytical skill set.



be easier at a younger age, whereas learning the intricacies of a domain may depend on accumulated experience, which emerges from motivation and well-invested time.

Although we do not have a strong body of evidence, our conjecture is that domain knowledge is necessary for data science but that the returns on domain knowledge are diminishing and that the relationship is moderated by the breadth of the analytical skills. Figure 1 illustrates the conceptual relationship between effectiveness, domain knowledge, and breadth of analytical skill set. The effectiveness of a data scientist might be measured by the size of the actionable opportunities they discover.

However, some analytical skills are more important than others. Table 1 provides examples of skills that are needed by a data scientist in SCM. What is interesting is that education in most of these disciplines progresses toward more focus and less breadth. This is not only true of the quantitative disciplines, but it is also true of the functional business disciplines. Training a data scientist would require a functional business discipline to inculcate toward more breadth, rather than more depth, as a student progresses in his/her educational path. This would be true for the training of both the practitioner and the researcher. Perhaps there should be two paths for Master and PhD degrees in SCM, one for domain knowledge creation and dissemination and one for SCM data science.²

You will probably notice the applied nature of the skills needed by an SCM data scientist in Table 1. However, this does not mean that a strong theoretical education is not needed in SCM. In fact, a strong theoretical knowledge is crucial, *within the area of SCM*. That is, an SCM data scientist needs a strong theoretical background in SCM along with an ability to apply analysis techniques from a broad variety of quantitative disciplines as well as business disciplines. You will notice that the first six disciplines in Table 1 are quantitative disciplines and the next four are business disciplines. Because data science is applied, tools are needed for application. It is notable that SCM is missing from the list. It is missing from the list because the SCM data scientist must understand both the theory and application of SCM. This is the domain, and the other disciplines are used for application of data to the SCM domain.

²It is tempting to think that this is the difference between marketing and marketing science, however, most PhDs in marketing science tend to have a very strong focus on one methodological area.

Table 1: Examples of skills needed by a supply chain management (SCM) data scientist

Discipline	SCM data scientist skill set	
	More important	Less important
Statistics	Broad <i>awareness</i> of many different methods of estimation and sampling	Derivations of methods and proofs of maximum likelihood estimation
Forecasting	Understanding <i>application</i> of qualitative and quantitative methods of forecasting	Understanding of underlying stochastic processes
Optimization	Numerical methods of optimization	Finding global optimal solutions
Discrete event simulation	Quick design and implementation of discrete event simulation models	Queuing theory
Applied probability	Using probability theory with actual data to estimate the expected value of random variables of interest	The theory of stochastic processes
Analytical mathematical modeling	Using numerical methods to estimate functions relating independent variables to dependent variables	Proving theorems
Finance	Capital budgeting	Efficient market theory
Economics	Determining opportunity cost	Macroeconomic theory
Marketing	Marketing science	Semiotics
Accounting	Managerial accounting	Debits and credits journal entries

We now propose a definition of SCM data science: *SCM data science is the application of quantitative and qualitative methods from a variety of disciplines in combination with SCM theory to solve relevant SCM problems and predict outcomes, taking into account data quality and availability issues.* We welcome research on this topic and would be pleased to publish it in the *Journal of Business Logistics*. Practitioners are looking for answers, and as researchers we should be proposing solutions, frameworks, and answers, all based on theoretically grounded research. We need theoretically based research to verify or reject the ideas in Table 1 and to expand them. At this point, Table 1 is simply conjecture. We invite research that would address which skill sets are needed by SCM data scientists.

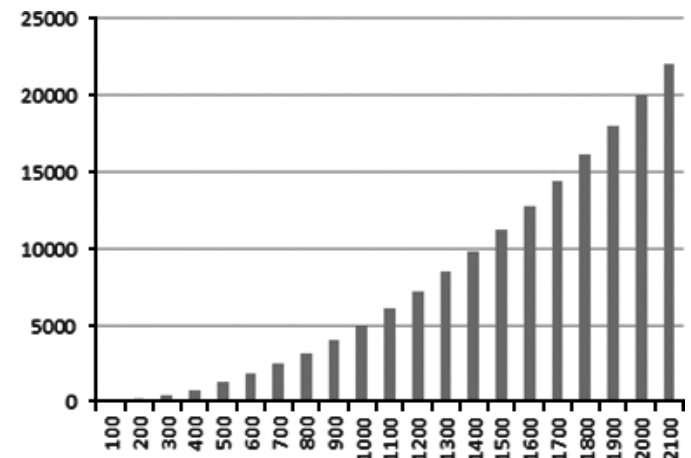
Some may object to our claim that SCM theory is needed by the SCM data scientist. However, theory is particularly important now that data and data variety are proliferating. Theory is particularly important for preventing false positives.³ False positives emerge when relationships between variables are discovered that do not really exist. The problem is that as the number of variables increases—that is, as the use of a theoretical data mining proliferates—the chances of false positives increases exponentially. In Figure 2, the horizontal axis is the number of variables and the vertical axis is the number of false positives when the probability of a given false positive is 0.01. Theory can help the research or manager avoid spurious decision making as they avoid falling prey to “apparent” relationships that do not really exist. As Barton and Court (2012) observe, “We have found that ... hypothesis-led modeling generates faster outcomes and also roots models in practical data relationships that are more broadly understood by managers” (p. 81).

Big data, which will be discussed below, is the source of the explosion of new variables that can be investigated, and therefore

the reason why we expect the number of false positives to grow exponentially. Using the *appropriate* logic and/or theory to build models prior to running predictive analytics is a key approach to mitigating the problems associated with false positives. So, again, although SCM data science is applied, it must be based on theory to guard against a proliferation of false positives, which result in wasted time and money. Again, Barton and Court (2012) comment that a “pure data mining approach often leads to an endless search for what the data really say” (p. 81).

Predictive analytics

Predictive analytics is a subset of data science. Recognition of the uniqueness of predictive analytics illuminates some interesting needs in research as is illustrated by Table 2.

Figure 2: Relationship between number of variables and number of false positives when the probability of a given false positive is 0.01.

³For a very interesting discussion on this topic, see Carraway (2012).

Table 2: Examples of research in predictive analytics

Comparative discipline	Dimension of interest	Predictive analytics research (examples)	
		Relevant	Less relevant
Statistics	Quantitative	Integrating quantitative and qualitative analysis	Improving Lagrange Multiplier tests for autocorrelation
Forecasting	Predicting the future	Using forecasting techniques for evaluating what would have happened under different circumstances	Deriving generalized estimators of seasonal factors
Optimization	Minimization and maximization	Assessment of the quality of the optimal solution and the ability to implement it versus near optimal solutions	Use of polyhedral functions in linear programming
Discrete event simulation	Quantitative analysis of a system in a stochastic setting	Discrete event simulation in a business process reengineering setting	Random number generation for discrete event simulation
Applied probability	Description of stochastic variables, expected values, and uncertainty	Applied probability along with application anchoring and framing affects from psychology	Asymptotic properties of Gaussian processes
Data mining	Search for patterns and relationships between a large number of variables with lots of data	Data mining preceded by logical and theoretical descriptions of possible relationships and patterns	Gibbs posterior for variable selection in data mining
Analytical mathematical modeling	Precise analysis using artificial and unrealistic assumptions for theorems and proofs	Methods of quickly and inexpensively modeling approximate relationships between variables while still using deductive mathematical methods	Proving inventory theorems that assume known, continuous demand with perfect information

Table 2 examines a sample of disciplines related to predictive analytics, selects a dimension of that discipline, and compares possible research topics and provides an example of a research area that would be more relevant to predictive analytics and an example of a research area that would be less relevant. Table 2 indirectly points to the distinction between predictive analytics and each of these quantitative disciplines. It also provides researchers with possible avenues of research that would be in the realm of predictive analytics.

Importantly, although predictive analytics is related to many long-standing quantitative approaches, it stands as distinct from each. Statistics is quantitative, whereas predictive analytics is both quantitative and qualitative. Forecasting is about predicting the future, and predictive analytics adds questions regarding what would have happened in the past, given different conditions. Optimization is about finding the minimum or maximum of a function, subject to constraints, whereas predictive analytics also concerns what would characterize a system that was not operating optimally. Analytical modeling is primarily about generating mathematical axioms and then proving lemmas and theorems, whereas predictive analytics attempts to quickly and inexpensively approximate relationships between variables while still using deductive mathematical methods to draw conclusions.

These are some examples of the differences in emphasis between predictive analytics and well known quantitative disciplines.

The topics in Table 2 have been examined in part, but additional research in these relevant areas would advance predictive analytics' ability to refine and improve supply chain decision making. Indeed, the *Journal of Business Logistics* is interested in predictive analytics research that is relevant to logistics and SCM. To that end, we propose definitions of logistics and supply chain predictive analytics:

Logistics predictive analytics use both quantitative and qualitative methods to estimate the past and future behavior of the flow and storage of inventory, as well as the associated costs and service levels.

SCM predictive analytics use both quantitative and qualitative methods to improve supply chain design and competitiveness by estimating past and future levels of integration of business processes among functions or companies, as well as the associated costs and service levels.

What is defined here as logistics predictive analytics and SCM predictive analytics has already existed in the past, it just lacked a

Table 3: Examples of causes of big data

Type of data	Volume	Velocity	Variety
Sales	More detail around the sale, including price, quantity, items sold, time of day, date, and customer data	From monthly and weekly to daily and hourly	Direct sales, sales of distributors, Internet sales, international sales, and competitor sales
Consumer	More detail regarding decision and purchasing behavior, including items browsed and bought, frequency, dollar value, and timing	From click through to card usage	Face profiling data for shopper identification and emotion detection; eye-tracking data; customer sentiment about products purchased based on “Likes,” “Tweets,” and product reviews
Inventory	Perpetual inventory at more locations, at a more disaggregate level (e.g., style/color/size)	From monthly updates to hourly updates	Inventory in warehouses, stores, Internet stores, and a wide variety of vendors online
Location and time	Sensor data to detect location in store, including misplaced inventory, in distribution center (picking, racks, staging, etc.), in transportation unit	Frequent updates for new location and movement	Not only where it is, but what is close to it, who moved it, its path to get there, and its predicted path forward; location positions that are time stamped from mobile devices

name. The idea is becoming so common that a name helps with communication about the concept. Reading Table 2 with these definitions in mind should provide a guide to appropriate research on logistics or SCM predictive analytics that would be of particular interest at the *Journal of Business Logistics*. Barton and Court (2012) highlight the growing value of advanced analytics:

“Advanced analytics is likely to become a decisive competitive asset in many industries and a core element in companies’ efforts to improve performance. It’s a mistake to assume that acquiring the right kind of big data is all that matters. Also essential is developing analytics tools that focus on business outcomes (p. 81)

Big data

Big data is unique because of the volume, variety, and velocity of the data, which today is widely available and much less expensive to access and store (McAfee and Brynjolfsson 2012). Volume can occur in many ways. There are more data because, among other reasons, the data are captured in more detail. For instance, instead of just recording that a unit sold at a particular location, the time it was sold and the amount of inventory at the time of the sale, is also captured. As another example, many companies that did not record daily sales by location and by stock-keeping unit to make inventory decisions, now do. Moreover, long global supply chains necessitate data capture at multiple points in the supply chain. In addition, there is now a proliferation of consumer sentiment data resulting from Tweets, Likes, and product reviews on websites. Such data must be analyzed and quantified. Software companies that provide algorithms designed to assess text from reviews and Tweets are cropping up

in large numbers. Table 3 provides examples of some of the causes of big data.

Table 4 provides examples of potential applications of big data within logistics and SCM practice. Each column of Table 4 represents a key managerial component of business logistics and each row represents a different category of user of logistics. This is not intended to be an exhaustive list of components of logistics nor of users of logistics.

Table 5 provides examples of research questions based upon management areas within logistics and SCM with reference to various sources of big data.

Back to basics

Finally, using management theory as a lens, we provide a few examples of research questions that are relevant to SCM in Table 6.

Demand for DPB professionals

We believe that there is increasing demand for professionals with competencies in DPB. As an example of overall interest, we show figures of the increasing numbers of Google searches for these terms. Figure 3 show a graph of numbers of Google searches⁴ since 2004 for various relevant terms. The scales on the y-axes are relative with 100 representing the peak number of searches.

As shown in Figure 3A, there were virtually no searches for “Data Science” until 2005 and none for “Data Scientist” until 2011. We believe the terms are catching on because of the

⁴<http://www.google.com/trends/explore#q=%22data%20science%22%2C%20%22data%20scientist%22&cmpt=q> (referenced March 22, 2013).

Table 4: Examples of potential applications of big data in logistics

User	Forecasting	Inventory management	Transportation management	Human resources
Carrier	Time of delivery, factoring in weather, driver characteristics, time of day and date	Real time capacity availability	Optimal routing, taking into account weather, traffic congestion, and driver characteristics	Reduction in driver turnover, driver assignment, using sentiment data analysis
Manufacturer	Early response to extremely negative or positive customer sentiment	Reduction in shrink, efficient consumer response, quick response, and vendor managed inventory	Improved notification of delivery time, and availability; surveillance data for improved yard management	More effective monitoring of productivity; medical sensors for safety of labor in factories
Retailer	Customer sentiment data and use of mobile devices in stores	Improvement in perpetual inventory system accuracy	Linking local traffic congestion and weather to store traffic	Reduction in labor due to reduction in misplaced inventory

Table 5: Examples of research questions

Type of data	Inventory management	Transportation management	Customer and supplier relationship management
Sales	How can sales data be used with detailed customer data to improve inventory management either in terms of forecasting or treating some inventory as “committed” based on specific shoppers requirements?	How can more current sales data be used to re-direct shipments in transit? How can sales data, integrated with detailed customer data, be used for more efficient and effective merge-in-transit operations?	How can more granular sales " data from the wide variety of sources that exist be used to improve visibility on the one hand and trust on the other, between trading partners?
Consumer	How can face profiling data for shopper identification, emotion detection, and eye-tracking data be used to determine which items to carry and stock at particular shelf locations?	How can delivery preferences captured in online purchases be used to manage transportation mode and carrier selection decisions?	How can customer sentiment about products purchased based on “Likes,” “Tweets,” and product reviews be used to collaborate on forecasts?
Location and time	How can sensor data used to detect location in store, be used to improve inventory management, including departmental merchandising decisions?	How can sensor data in the distribution center be used to anticipate transportation requirements?	How can location and time-stamp data of shoppers be used for collaborative assortment and merchandising decisions?

increased need for people with skill sets that can deal with big data. Figure 3B shows a graph of searches⁵ for “Predictive Analytics.” Like “Data Science,” searches for “Predictive Analytics” essentially began in 2005 with significant growth after 2009. Fig-

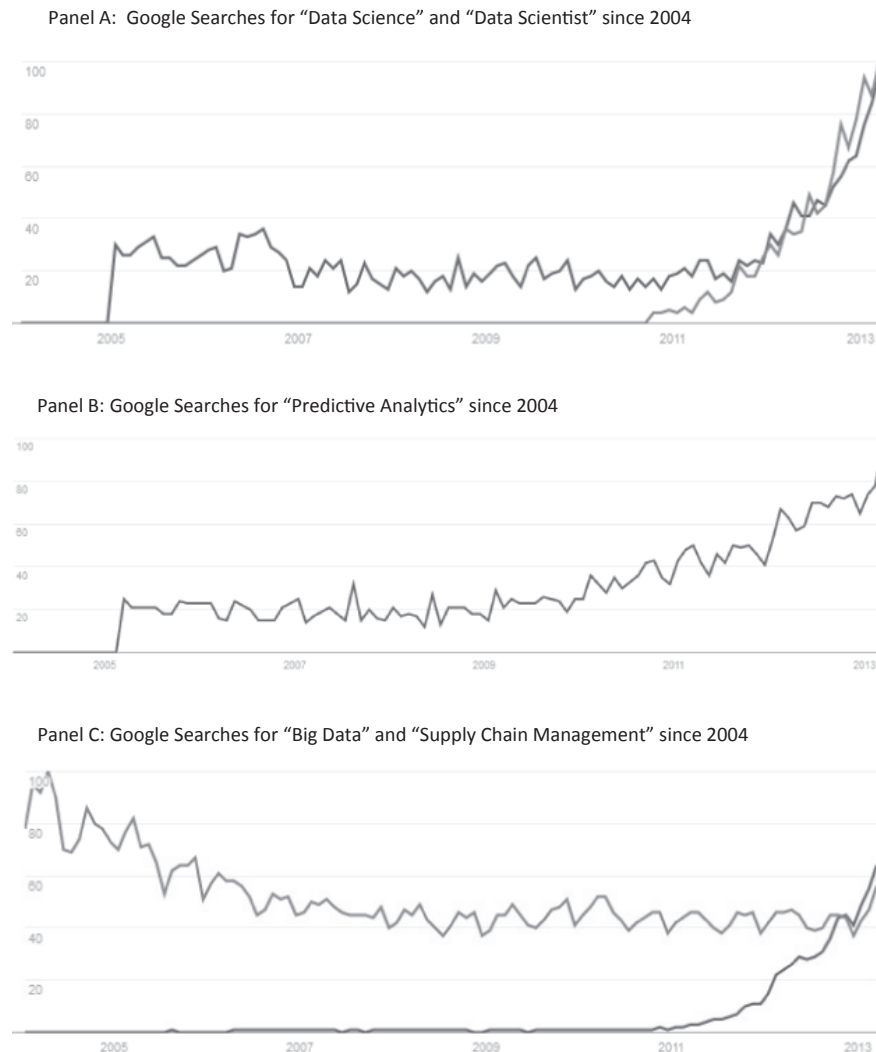
⁵<http://www.google.com/trends/explore#q=%22predictive%20analytics%22&cmpt=q> (referenced March 22, 2013).

ure 3C shows a graph of searches⁶ for “Big Data,” with “Supply Chain Management” as a reference. As you can see, this is the first year “Big Data” had more searches than “Supply Chain

⁶<http://www.google.com/trends/explore#q=%22big%20data%22%2C%20%22supply%20chain%20management%22&cmpt=q> (referenced March 22, 2013).

Table 6: Examples of big data research questions that are relevant to supply chain management (SCM), stemming from management theory

Theory	Research question
Transaction cost economics	How does the existence of big data affect the reduction in internal transaction costs vis-à-vis external transaction costs and how is this affecting the size of logistics organizations and the structure of supply chains?
Resource-based view	Can SCM data science be developed as a resource that is valuable, rare, in imitable, and nonsubstitutable?
Contingency theory	How can big data and SCM data science be used by logistics managers to meet internal needs and adjust to changes in the supply chain environment?
Resource dependence theory	How does the ability to use big data for SCM decisions affect a firm's power in comparison with its suppliers or customers?
Agency theory	How does the proliferation of big data affect the agency costs associated with the use of third party logistics?
Institutional theory	How do differences in freedom of information between countries affect firms operating under these different institutions in terms of their abilities to leverage big data in the supply chain?

Figure 3: Google searches for growth of interest in DPB professionals.

Management.” We do not think big data will become more important than SCM; it is shown here just to illustrate how popular the phrase is becoming.

Clearly, Figure 3 shows that interest in DPB is growing exponentially. We believe that the phenomena underlying this trend create a number of challenges and opportunities for our

discipline. We have only begun to explore the possibilities, and we need to more creatively ask informed decisions about how big data can improve supply chain design, relationship development, improve customer service systems, and manage day-to-day value-added operations.

CONCLUDING DISCUSSION

Although “Big data” has become a contemporary buzzword, it has significant implications in our discipline, and presents an opportunity and a challenge to our approach of research and teaching. We can easily see how data science and predictive analytics apply to SCM, but sometimes find it more difficult to see the direct connection of big data to SCM. Therefore, we would like to see research published in the *Journal of Business Logistics* that brings clarity to the relevance of big data, and DPB in general within the supply chain domain. Here is how you can participate:

1. Submit manuscripts dealing with DPB.
2. Submit Forward Thinking articles on DPB.
3. Send us a proposal for a Special Topics Forum on DPB.
4. Design a Thought Leader Series on DPB.
5. Start a new research project on DPB, using your existing research skills and domain knowledge.
6. If you have ideas about how we can promote research on DPB outside of these categories, please email us and let us know your thoughts.

This edition of the *Journal of Business Logistics*, Volume 34, Issue 2, represents the mid-point of our five-year commitment as co-editors-in-chief. We have been diligent in this commitment to serve not only as stewards and administrators of the journal but also to span boundaries to provide leadership and direction for research in our discipline. We believe the intersections of our discipline with data science, predictive analytics, and big data will create significant challenges for educating future supply chain leaders. Yet, they also provide opportunities for research to advance knowledge in our disci-

pline in a way that is both rigorous and relevant. Indeed, we believe it is a real doozy for knowledge creation and dissemination in SCM.

ACKNOWLEDGMENTS

We thank the following individuals for their helpful comments, edits, and input on earlier drafts of this manuscript: Yao (Henry) Jin, John Saldana, Travis Tokar, Christopher Vincent, Xiang Wan, and Brent Williams. Their input resulted in a significant improvement to the manuscript.

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A Compendium of Multi-Item Scales Utilized in Logistics Research (2001–10): Progress Achieved Since Publication of the 1973–2000 Compendium

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Forty years have passed since the first multi-item measurement scales were employed through survey research to better understand important logistics concepts. Through the years, four leading logistics journals have published research containing a total of 1,670 scales within 283 articles. A 42% increase in utilization has occurred during the most recent decade. The research fully discloses the conceptualization, composition, and properties of the multi-item survey scales utilized in the study of logistics and supply chain management theory and practice. By documenting each scale published from 2001 to 2010, the authors make comparisons with results from the 1973–2000 study. Primary findings indicate an increase in the percentage of research utilizing multi-item scales, and an increase in the application of confirmatory factor analysis (CFA) has assisted in producing more highly acceptable psychometric properties of the scales. This implies that researchers are utilizing more highly developed scales and following strict scale-development procedures for building more robust scales to measure concepts important for advancing our knowledge of logistics and supply chain management. The top four conceptual categories for the scales have remained the same since 1973 and account for greater than half of the scales published. Eight additions to the categories since 2001 pertain greatly to controlling our supply chains for customer, brand, and overall security benefits. The compendium of scales provides a central document to reference as researchers seek to employ highly developed survey measures.

Keywords: survey; measurement; scales; logistics; metrics; reliability; supply chain management

Transportation Journal was one of the first journals to publish logistics research beginning in 1961, but it was not until 1973 when the first article employing multi-item scales in leading logistics journals appeared in the *International Journal of Physical Distribution* which is now the *International Journal of Physical Distribution and Logistics Management* (DeHayes 1973). Ever since DeHayes (1973) utilized such measurement scales to study railroad on-time performance, researchers of transportation, logistics, and supply chain management have steadily increased the development and reliance on multi-item scales for their research.

Multi-item scales are utilized in survey research to measure concepts that are not easily quantifiable with a single item on a questionnaire (Dunn et al. 1994; Mentzer and Kahn 1995; Mentzer and Flint 1997). Well-conceptualized latent variables (i.e., constructs) supported by highly developed and refined measurement scales allow researchers the certainty needed for exploring and confirming business concepts and relationships among variables for theory development. Construct measurement and hypothesis testing are influenced by the level of validity and reliability of multi-item scale survey data. Scholarship and disciplines advance, in part, as the tools utilized by researchers help assure that what is measured is what was intended to be measured.

Nearly four decades have passed since publication of the first multi-item scale utilized in a leading logistics-focused journal. Keller et al. (2002) documented, categorized, and evaluated the

development and utilization of multi-item scales in logistics research starting with DeHayes (1973) through the year 2000. Results from the study indicate a significant growth in the number of articles employing multi-item scales and the number of scales developed and utilized to better comprehend logistics concepts and relationships. The research also established that the scales used to measure logistics concepts have, over time, improved in the range of items per scale and in the average strength in coefficient alpha reported.

As an extension of Keller et al. (2002), the current study sets forth to document the 10-year progress made from 2001 to 2010. More specifically, the core objectives of the research include:

1. To identify and document in a compendium, the multi-item scales published in leading logistics journals from 2001 to 2010. This will offer broad-scale categorizations for researchers to more easily reference existing scales and related articles for future research.
2. To offer a descriptive comparison of scale categories with the results from Keller et al. (2002).
3. To document and compare with the results from Keller et al. (2002), the scale development techniques utilized to assess measurement validity and reliability.
4. To offer a descriptive comparison of the research results between the *Journal of Business Logistics* and the *Journal of Marketing*.
5. To identify opportunities for the future development of scales utilized in logistics survey research.

The research followed the method for identifying and categorizing the scales that was employed by Keller et al. (2002) and will be discussed in the next section. Results and observations then will be discussed to disclose scale characteristics and the

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primary tools of evaluating the utility of the scales. Implications will be discussed with the goal to provide researchers directions for the use of existing scales and for the development of future scales important for advancing logistics as a discipline. Appendix S1 contains each multi-item scale, its psychometric characteristics, and the authors who *utilized* the scale in the leading logistics journal publications from 2001 through 2010.

SCALE IDENTIFICATION AND CATEGORIZATION PROCESS

Multi-item scales documented in the compendium (Appendix S1) were obtained from research published in the *International Journal of Logistics Management (IJLM)*, *International Journal of Physical Distribution and Logistics Management (IJPDLM)*, the *Journal of Business Logistics (JBL)*, and *Transportation Journal (TJ)*. Keller et al. (2002) utilized the four journals because they are known to be the leading journals publishing logistics research (see, e.g., Fawcett et al. 1995; Carter 2002; Gibson and Hanna 2003; Autry and Griffis 2005; Zsidisin et al. 2007; Menachof et al. 2009; Gorman and Kanet 2011; Liao-Troth et al. 2012). Our research also reports on the survey scales published in these four journals because of the consistent rankings of the journals publishing logistics research and because our research objectives set forth to draw comparisons from the three decades evaluated by Keller et al. (2002) to the most recent decade of 2001–10.

Doctoral students utilizing survey research are instructed in the proper design and evaluation of scales utilized to measure latent constructs. Multiple survey questions are employed to attain a more robust measurement of a concept over that achieved by a single item on a questionnaire. Researchers may evaluate such robustness through validity and reliability analysis (Dunn et al. 1994; Mentzer and Flint 1997). By following rigorous scale development procedures to achieve highly valid and reliable measures, researchers are better equipped to employ the measures for theory testing and development.

Appendix S1 contains a categorical listing of multi-item scales and the available information concerning the scales' validity and reliability that have been published in leading logistics journals. This was the primary intent of the research, so that, researchers studying logistics and supply chain management theory and concepts may have a central document with which to access scales previously developed and tested. While the authors have done their very best to identify and properly document each scale and its accompanying support for its psychometric properties, it is possible with such a large undertaking to have made an occasional error. If such an error exists, it is completely unintentional and the authors offer apologies in advance.

The four journals, *IJLM*, *IJPDLM*, *JBL*, and *TJ*, were independently reviewed by four authors to provide a systematic collection of the scales from each volume and issue. It is important to note that a specific requirement was that the scale be *utilized* in the research; however, it did not have to be originally developed by the authors utilizing it. Scales were required to have at least two items reported, and the researchers must have indicated that some minimal procedures were taken to establish the usefulness of the scale. This could be accomplished, for example, through

an indication that a preliminary test was conducted with a target sample to assess the wording of the questions comprising the scale.

The procedure followed included the following:

1. Researchers obtained copies of all articles appearing in the four journals from 2001 to 2010.
2. Four researchers independently reviewed each article in each issue to identify articles employing multi-item scales.
3. The researchers compared their findings and any discrepancies were discussed among the researchers to ensure that all "scale" articles were properly identified.
4. Statistics pertaining to scale validity and reliability that were reported were documented.
5. A Delphi technique was utilized by the authors to offer general categorization of the scales.

RESULTS AND DISCUSSION

Information and data pertaining to the scales appears in Appendix S1. An alphabetical listing of the categories used to organize the scales into broad descriptions appears at the start of Appendix S1. Scales appear by: Alphabetized category and then alphabetized construct/scale name given by the author(s). Primary information pertaining to the scale, if provided by the author(s), includes author name(s) and year of publication, description/definition of the construct, description of the sample utilized, and any reference that may have indicated that the scale was derived from another source. Statistics pertaining to the reliability, validity, internal consistency, and unidimensionality are then provided. Last, the Likert-type scale values and anchors are provided and followed by an exact wording of the items provided by the author(s) in the article. Here is an example of an entry in Appendix S1:

Collaboration (Sinkovics and Roath 2004); Involves an independent relationship where the parties work closely together "to create mutually beneficial outcomes for all participants" (Jap 2001, 87); 142 logistics managers from companies in England, Scotland, Wales, and Northern Ireland involved in outsourcing activities using third-party logistics (3PLs) (see also Jap 1999).

*Coefficient alpha (.88); Factor score range (.66–.90); Confirmatory factor analysis ($\chi^2 = 333.03$, $df = 237$, $p\text{-value} \leq .001$, NNFI = .965, CFI = .970, RMSEA = .036, IFI = .971); Item loading t -values (9.17–14.19).

*7-point scale—(1) Strongly Agree to (7) Strongly Disagree; Our company and the service provider work together to exploit unique opportunities in the market; Both companies look for synergetic ways to do business together; Our companies work together to develop new ideas; We continually share proprietary information with each other.

IJLM, *IJPDLM*, *JBL*, and *TJ* published a total of 976 articles in 183 issues from 2001 to 2010. Of the total, 167 articles or approximately 17% utilized multi-item scales in their analysis. From 1961 to 2000, only 5.6% of the research articles documented the usage of multi-item scales (Keller et al. 2002).

Table 1 indicates the total number of scales reported in the articles from 2001 to 2010 to be 980 scales. Comparing this to the first three decades of logistics research (690 scales reported), the discipline has achieved a 42% increase within the past 10 years, alone [(980–690)/690]. It is clear that researchers in logistics and supply chain management have found survey research employing multiple items increasingly useful for better capturing the conceptual domains of constructs not directly measurable utilizing ratio metrics.

Scale categorizations

Table 1 lists the categories utilized by the authors to offer broad categorization of the scales. First, scale descriptions and items provided in each article were reviewed and categorized by each author and discrepancies between authors were discussed and resolved. Four iterative rounds were necessary to come to full agreement on the categorization of the scales. It is important to note, however, that it was not our intention to completely content analyze each scale and the conceptualization provided in the research; rather, the categorization is used to organize the scales in a manageable manner so that researchers in the future may peruse categories to locate scales useful to their research. Second, the authors started grouping scales under the categories resulting from Keller et al. (2002). Scales were added, some groupings changed, categories were added, and some dropped.

Performance and Quality contained 188 scales, accounted for 19.2% of the total scales reported, and ranked first in our categorization. In comparison, Keller et al. (2002) reported this category as ranked second with 117 scales totaling 17% of the total scales. Examples of this category include:

Consequence (Inbound) (Svensson 2002); The negative consequences of disturbances, that is, the degree of negative impact in the firm's inbound logistics flows. Sample item: How often or seldom do the disturbances in your company's inbound logistics flows from subcontractors cause downtimes in the manufacturing processes?

Financial Performance (Corsten and Felde 2005); Return on assets (ROA), return on sales, and the improvement of both measures compared to the industry average. Sample item: Compared to the average in our industry our ROA has been considerably better over the last three years.

Channel Relationships ranked second in this study (184 scales; 18.8% of total scales reported). Again, the percentages were similar to the results in Keller et al. (2002) with 17.4% of the total reported scales, but the category ranked first from 1973 to 2000. Examples of this category include:

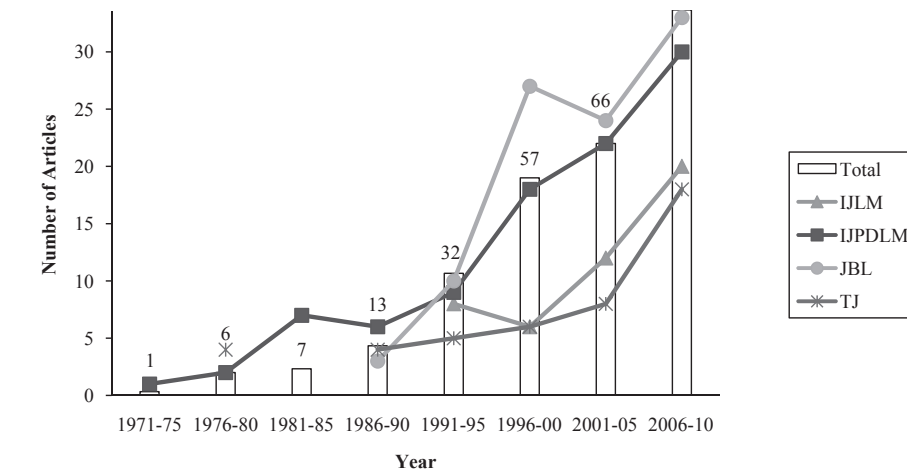
Altruism (Interorganizational Citizenship Behaviors) (Autry et al. 2008); Behavior directed at helping a partner firm in solving problems or acquiring needed skills/knowledge. Sample item: When our supplier is unable to fulfill certain responsibilities, we try to be understanding.

Attachment (Knemeyer and Murphy 2005); Describes genuine feelings toward the other company or that company's employees. Sample item: In times of need, this third party has gone out on a limb for us.

Completing rankings three and four, Internal Relationships/Personnel (third) and Information Sharing, Processes, and Technology (fourth) remained in their respective positions across both studies. While positions one and two swapped categories, the top

Table 1: Scale categories

Rank	Category	# of scales	% of total	Cumulative %
1	Performance and quality	188	19.2	19.2
2	Channel relationships	184	18.8	38.0
3	Internal relationships/Personnel	133	13.6	51.5
4	Information sharing, processes, and technology	113	11.5	63.1
5	Customer satisfaction and loyalty	52	5.3	68.4
6	Flexibility, responsiveness, and just-in-time	44	4.5	72.9
7	Organizational characteristics	37	3.8	76.6
8	Regulation-safety	26	2.7	79.3
9	Customer orientation	24	2.4	81.7
10	Logistics and transportation operations	24	2.4	84.2
11	Global/International	21	2.1	86.3
12	Environmental characteristics	20	2.0	88.4
13	Inventory	20	2.0	90.4
14	Security	20	2.0	92.4
15	Supplier selection	20	2.0	94.5
16	Corporate social responsibility	15	1.5	96.0
17	Reverse logistics	11	1.1	97.1
18	Brand image	10	1.0	98.2
19	Measurement	10	1.0	99.2
20	Education	8	0.8	100.0
	Total	980		

Figure 1: Articles employing multi-item scales in leading logistics journals.*

*The bar chart is on a separate scale from the line charts.

four categories were the same for both studies and accounted for more than half of the scales reported (2001–10 = 63.1% cumulative; 1973–2000 = 56.4% cumulative).

Examples of Internal Relationship/Personnel include:

Behavior Management (Change Process-Refreezing Phase) (Greer and Ford 2009); Consists of activities that provide feedback on individual performance and incentives for acting in a manner that promotes and reinforces desired behavior during change implementation. Sample item: Were employees rewarded for working to support the change effort?

Centralization (Diffusion of Contingency Planning Process) (Skipper et al. 2009); Degree of decision-making concentration. Sample item: Participation of subordinates in organizational decision making is encouraged.

Examples of Information Sharing, Processes, and Technology include:

Adopting Information Technology (Zacharia and Mentzer 2004); The utilization of information technology in the industry. Sample item: How extensively is real-time product tracking used in your industry?

Business-to-Business (B2B) E-Commerce Implementation (Iyer et al. 2004); Encompasses electronic data and information exchange (EDI) technology and application tools such as the Internet and EDI that facilitate integration and management of core businesses processes between key supply chain partners. Sample item: Rate the extent to which B2B e-commerce has been used to generate cross-firm process integration with key trading partners

Table 1 also indicates the category Customer Satisfaction and Loyalty jumped from 13th (11 scales and 1.6%) (Keller et al. 2002) to 5th (52 scales and 5.3%) in this study.

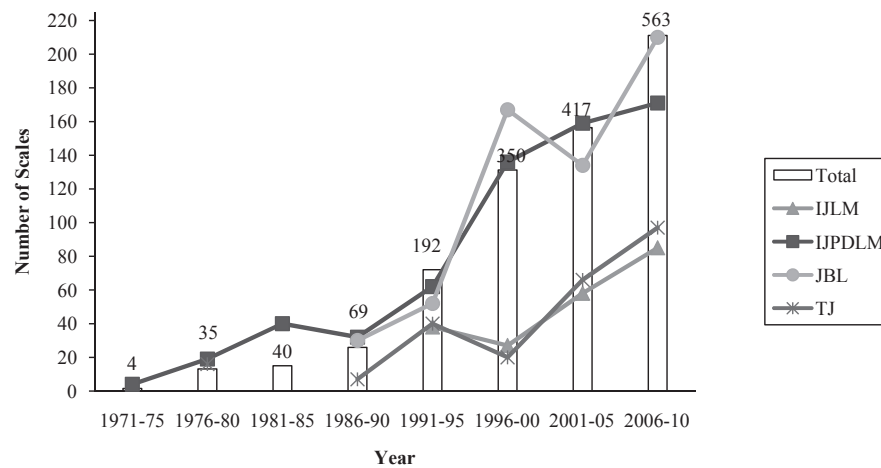
Benevolence (Hofer et al. 2009); Extent that the customer believes that the 3PL has intentions and motives beneficial to

the customer when new conditions arise. Sample item: The 3PL's representative—Has made sacrifices for us in the past. *Customer Loyalty* (Cahill et al. 2010); Intention of a buyer of logistics services to purchase the same services (retention) and additional services (expansion) from the current provider in the future, as well as the buyer's activities in recommending this provider to others (referral). Sample item: Within our organization, we have recommended preferential consideration of this LSP for further projects.

While most other categories have remained similar in percent contribution over the two studies, new to the categorization are Regulation-Safety; Customer Orientation; Security; and Supplier Selection with each contributing 2%–2.7% of the total scales utilized from 2001 to 2010. The categories seem to be related in that safety and security transcend the categories, including customer orientation and supplier selection. There is no doubt that the terrorist attacks on U.S. soil have initiated the need for greater study of securing our supply chains and keeping customers and stakeholders safe, as well as the general public.

SCALE CHARACTERISTICS AND TRENDS

Figure 1 indicates an overall upward trend for the number of articles published in the journals containing research utilizing multi-item scales from 1973 through the past decade 2001–10. Compared to the first 30 years of research published in the journals, since 2000 researchers have published approximately 44% more articles utilizing latent variables measured with scales (116 and 167, respectively). The same comparison by individual journal indicates an increase for *IJLM* (129%), *IJPDLM* (21%), *JBL* (57%), and *TJ* (37%). A closer observation indicates an approximate 88% increase from 2001 to 2010 (167 articles utilizing scales) over that appearing from 1991 to 2000 (89 utilizing scales). The results are important indicators that the discipline is advancing logistics and supply chain understanding through

Figure 2: Number of multi-item scales in leading logistics journals.*

*The bar chart is on a separate scale from the line charts.

greater utilization of well-developed survey scales to measure critical concepts within theories and nomological networks.

Trends comparing the number of multi-item scales utilized in the four leading logistics journals appear in Figure 2. Data indicate a 42% increase in the most current decade (2001–10 = 980 scales) compared with the previous three decades (1971–2000 = 690 scales). While *IJLM* with a 120% increase [(143–65)/65] and *TJ* with a 96% increase [(163–83)/83] realized the greatest jumps in usage, *JBL* and *IJPDLM* led the way in scale utilization, overall, and within the most recent decade (344 scales and 330 scales, respectively). In fact, as *IJPDLM* and *JBL* remain consistently strong in publishing research employing multi-item scales, *IJLM* and *TJ* have made significant progress, as well. This is evidenced by the narrowing “gap” between the data representing *IJPDLM* and *JBL* for the period 1971–2000 (542 scales, total) and *IJLM* and *TJ*, collectively for the same period (148 total scales, a 266% difference), to the “gap” for the period 2001–10, a 120% difference (*IJPDLM* and *JBL* = 674 scales; *IJLM* and *TJ* = 306 scales [(674–306)/306]).

The results are very positive for all journals. This is further apparent as the journals, in total, generated an approximate 80% increase in utilization from the 10 year period 1991–2000 to the most current 10 year period (2001–10).

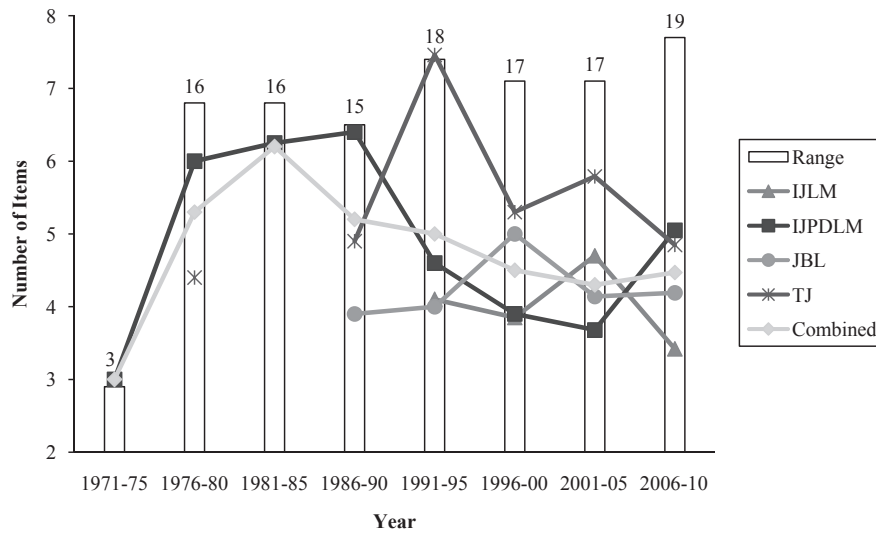
Figure 3 illustrates the range pertaining to the number of items per scale in the bar chart (a separate scale of 3–19). The y-axis scale, 2–8, applies to the line graphs and the average number of items per scale by journal and for all journals combined. Five scales were deemed outliers and were removed from the analysis depicted in Figure 3 [scale item outliers: 2001 *TJ* (20); 2003 *JBL* (20); 2005 *IJLM* (30); 2010 *IJPDLM* (24 and 27). While there have been some recent shifts upward in average items per scale for *IJPDLM* (2001–05 = 3.68 and 2006–10 = 5.05) and *JBL* (2001–05 = 4.14 and 2006–10 = 4.19) and declines in average items per scale for *IJLM* (2001–05 = 4.70 and 2006–10 = 3.42) and *TJ* (2001–05 = 5.79 and 2006–10 = 4.85), all of the journals’ averages continue to be acceptable and relatively consistent for the past 15 years. Moreover, as would be expected, the overall combined average number of items per scale has remained consistent for the past 15 years (4.5 average

items in 1996–2000; 4.3 average items in 2001–05; and 4.47 average items in 2006–10).

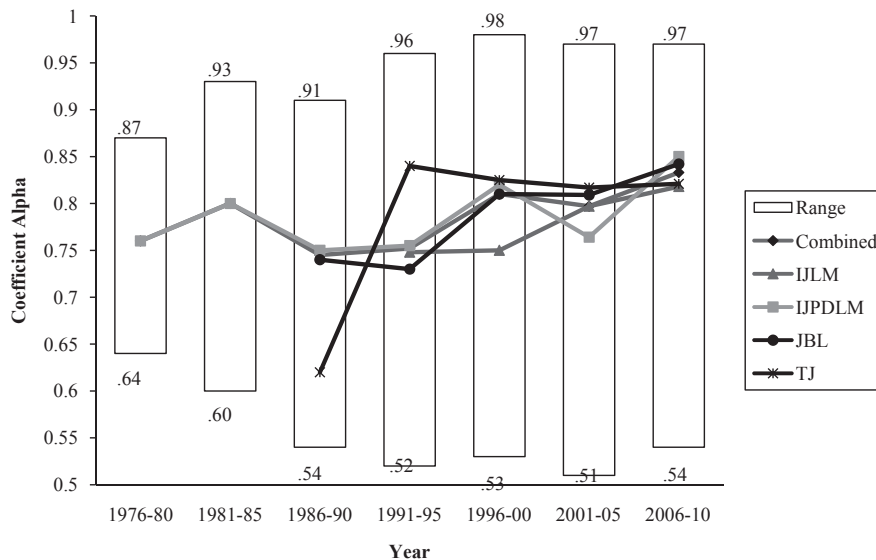
The combined average coefficient alpha (.80 for 2001–05 and .83 for 2006–10) indicated in Figure 4 shows that the reliability and internal consistency of the scales utilized in leading logistics journals are well within the range advocated in the literature. Average alphas for each journal also meet the requirement, and indicate that overall, the items representing logistics scales published within the past 10 years are well structured. The ranges of coefficient alpha reported (.51–.97 for 2001–05 and .54–.97 for 2006–10) are broad and are of some concern as Keller et al. (2002) also found. The concern centers on the utilization of scales that fall below the acceptable range of .60 for exploratory research when relying on the scales for hypothesis testing and theory development. Researchers, editors, and reviewers must work to ensure that the measures employed are of highest psychometric property standards so that we do not draw conclusions about hypotheses based on data that may be a function of poorly conceptualized and poorly worded items.

Table 2 compares each journal and the journals combined based on articles reporting of commonly accepted validity and reliability analysis and results. Progress associated with the most recent decade (2001–10) is also compared with that of the period 1971–2000 (Keller et al. 2002). In all cases, the number of journal articles utilizing multi-item scales has increased and with the overall increase being 44%. Perhaps of greatest significance is that researchers have reported the results of CFA more over the past 10 years than ever before in the history of each journal. More than half of the “scale” articles in both *IJLM* (350% increase) and *JBL* (239% increase) reported employing CFA, while 42% of the articles published in *IJPDLM* and 46% published in *TJ* also included CFA’s representing a substantial increase from nine articles and zero articles, respectively, from the years 1971–2000.

Compared to the traditional factor analysis and principle components analysis, CFA offers a more rigorous test of the psychometric properties related to a construct’s measurement model survey items. CFA is utilized to test and “confirm” the properties

Figure 3: Range and average number of items per scale in leading logistics journals.*

*2 is the minimum number of items per scale for all ranges. The bar chart is on a separate scale from the line charts.

Figure 4: Range and average coefficient alpha in leading logistics journals.*

*Coefficient alpha was first introduced in 1977. Combined includes the average of *IJLM*, *IJPDLM*, *JBL*, and *TJ*. The bar chart and line chart are on the same scale.

of well-developed scales as opposed to *exploring* the underlying factor structure of a series of variables that originally may not have been designed to measure a single dimension concept. The results in Table 2 are encouraging for the discipline as they clearly indicate a combined reduction in traditional exploratory factor and principle components analysis while disclosing a significant increase in the application of CFA within articles employing multi-item scales. This implies that researchers are, indeed, utilizing more highly developed scales and/or following strict scale-development procedures for building more robust scales to measure concepts important for advancing our knowledge of logistics and supply chain management. While *TJ* is the only journal with an increase in reporting factor and principle components analysis, the “scales” articles in *TJ* also went from

no CFA reports between 1971 and 2000 (Keller et al. 2002) to 46% in 2001–10.

Over 50% of the publications indicated that pretests were performed, and in all cases, more than 73% of the research employing multi-item scales reported reliability statistics. *IJLM* (22%) and *JBL* (25%) articles most often reported assessments of discriminant validity by comparing average variance extracted (AVE) from shared variance (SV) of pair-wise constructs.

Independently by journal and collectively, the results are strong indicators that researchers of logistics and supply chain management have made significant progress over the past 40 years and in particular over the past decade in building a substantial base of valid and reliable multi-item measures representing the core concepts of the discipline.

Table 2: Percentage of articles reporting validity and reliability assessments in leading logistics journals (2001–10)

	IJLM	IJPDLM	JBL	TJ	Combined
Pretest	(57) 47	(38) 42	(58) 68	(41) 38	(47) 52
Factor/Principal components analysis	(64) 47	(64) 50	(93) 65	(53) 62	(72) 56
Coefficient Alpha/Kuder Richardson 20 reliability	(50) 75	(56) 73	(75) 88	(65) 77	(63) 79
Item-to-total correlations	(7) 6	(4) 8	(28) 14	(6) 12	(13) 10
Confirmatory factor analysis	(14) 63	(9) 42	(23) 78	(0) 46	(13) 59
Average variance extracted compared to shared variance	(0) 22	(0) 2	(8) 25	(0) 0	(3) 13
Total number of articles	(14) 32	(45) 52	(40) 57	(17) 26	(116) 167

Coefficients within parentheses were reported by Keller et al. (2002) for 1971–2000.

Comparisons of peer disciplines' top journals: *Journal of Business Logistics* and *Journal of Marketing*

Similar to the results found by Keller et al. (2002), Table 3 indicates that the *Journal of Marketing (JM)* ($n = 159$), compared with *JBL* ($n = 57$), has published more than two and a half times the number of articles employing multi-item scales from 2001 to 2010. *JBL* published a 111% increase in articles utilizing multi-item scales within the most recent decade. *JM* also had a 152% increase. The number of scales reported had a similar jump for both journals within the past decade (*JBL*, 113% increase; *JM*, 169% increase). Substantial increases in each category were achieved for both journals.

Observations relating to the properties of the published scales within the two journals reveal very positive similarities between *JBL* and *JM*. Over the past decade, *JBL* scales contained an average of 4.17 items per scale, while *JM* published scales had an average of 3.99. Average coefficient alpha for each was above the baseline advocated in the literature (*JBL* = .83; *JM* = .89), and the researchers utilizing scales provided the results of CFA over 70% of the time (*JBL* = 77%; *JM* = 72%). While this was an increase in use for *JM* (1996–2000, 65%), it was a substantial increase for *JBL* compared to the utilization of CFA from 1996 to 2000 (26%) and from 1971 to 2000 (23%).

Table 3 indicates that pretests were reported in more than half of the “scales” publications (*JBL* = 68%; *JM* = 57%) and coefficient alpha was reported well over 85% of the time (*JBL* = 88%; *JM* = 91%). While discriminant validity assessments utilizing AVE compared with SV were reported in only 25% of the *JBL* articles and 48% in *JM*, both percentages were greater than previous years. Based on the entire sample, however, it became known that researchers were utilizing CFA analysis to evaluate discriminant validity as well as unidimensionality. Researchers interpret the strength of the loadings on the intended constructs and the less than 100% correlation between constructs as evidence of discriminant validity. The AVE and SV analysis is a more rigorous evaluation of discriminant validity, and while both journals showed increases in its usage, researchers are encouraged to increase their reliance on the analysis.

CONCLUSION

Our data show substantial and sustained advancement in the composition and construction of the multi-item measurement

Table 3: Descriptive statistics of multi-item scales in *Journal of Business Logistics* and *Journal of Marketing* (2001–10)

	JBL	JM
Number of articles with scales	(27) 57	(63) 159
Number of scales	(167) 356	(505) 1,356
Average number of items per scale	(4.92) 4.17	(4.48) 3.99
Average coefficient alpha	(.81) .83	(.81) .89
Percentage of articles reporting		
Pretest	(59) 68	(60) 57
Factor/Principal components analysis	(81) 65	(46) 23
Coefficient Alpha/Kuder Richardson 20 reliability	(93) 88	(89) 91
Item-to-total correlations	(33) 14	(22) 8
Confirmatory factor analysis	(26) 77	(65) 72
Average variance extracted compared to shared variance	(11) 25	(32) 48

Note: Coefficients within parentheses were reported by Keller et al. (2002) for 1996–2000.

scales representing a core element of the foundation supporting logistics and supply chain management research. Assessment of the articles appearing in four leading logistics research journals, *IJLM*, *IJPDLM*, *JBL*, and *TJ*, indicates an increase/improvement in the following areas:

1. Breadth and depth of scale categories representing core concepts within the discipline.
2. Number of articles employing multi-item scales.
3. Number of multi-item scales utilized.
4. Average coefficient alpha measuring reliability.
5. Average number of articles reporting the usage of pretesting.
6. Average number of articles reporting the usage of CFA.
7. Average number of articles reporting the usage of AVE compared to SV for assessing discriminant validity.

Theory development requires strong measures to assure the final research results fully and accurately represent the theory being tested. Poorly designed measures may mask the signifi-

cance, magnitude, and direction of relationships among constructs within a theoretical model. It is clear that logistics and supply chain researchers have amassed a robust foundation of multi-item measures that have important valid and reliable characteristics. Researchers employing the scales for empirical testing of hypotheses may have greater confidence that their results are, indeed, a function of the theory and not an anomaly of the measures.

Researchers of performance, quality, relationships (internal and external), information sharing, processes, and technology have the greatest bank of scales developed and are encouraged to continue utilizing and refining the strength of these 618 scales. Although these topics represent 63% of the cumulative total scales over the most recent decade, it should also be indicative of the topics of greatest interest to researchers, editors, reviewers, and practitioners.

Topics new to the scale categories from that published in Keller et al. (2002) include regulation, safety, customer orientation, security, supplier selection, reverse logistics, brand image, and education. These represent a need for further exploration into the concepts important for building knowledge specific to each area. Perhaps a common element among the “new” categories is the need to better develop our knowledge pertaining to controlling our supply chains for customer, brand, and overall security benefits. Knowledge within these topics is in greater need of exploration and development.

The driving force for this research was to provide researchers a central document to reference when searching for developed measures to utilize in future studies. The compendium of scales appearing in Appendix S1 accomplishes this goal. It also may assist in identifying additional articles that are related to the concepts and theories of immediate importance to researchers.

Along with studies of journal rankings and impact factors, our comparisons of the statistics related to the multi-item scales utilized in *JBL* and *JM* over the most recent decade (2001–10) offer significant indications of the high quality and rigor of the research published in *JBL*. It is hoped that the entire results of this study further assist professors in justifying the strength of our top logistics journals to our peers, chairpersons, deans, and others that require support for rendering tenure and promotion decisions.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Appendix S1. The material in the Appendix was derived directly from original articles.

SHORT BIOGRAPHIES

Scott B. Keller (PhD University of Arkansas) is Professor of Logistics and Marketing at the University of West Florida. He has been on faculty at Penn State and Michigan State. His research interests include issues in personnel development and performance, and the development of a market oriented culture within logistics operations. He has conducted research for numerous corporations and his work has appeared in leading logistics journals. He is the editor of the *International Journal of Logistics Management* and is on the editorial boards of the leading logistics research journals. His managerial experience is in motor carrier operations, warehousing, and ocean freight terminal operations.

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A Multidisciplinary Approach to Supply Chain Agility: Conceptualization and Scale Development

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Although agility has been identified as one of the most important issues of contemporary supply chain management, the theoretical basis for understanding supply chain agility is fragmented. This research addresses the gap related to the ambiguity surrounding the dimensions and definitions of firm supply chain agility by employing a multidisciplinary literature review to gain an in-depth understanding of agility. In addition, a comprehensive measurement instrument that draws on the foundations of social and life science theory is developed and empirically validated. The results of the research indicate that firm supply chain agility is composed of five distinct dimensions including alertness, accessibility, decisiveness, swiftness, and flexibility. Based on these elements, a comprehensive definition of firm supply chain agility is developed for further theoretical testing of the concept.

Keywords: agility; firm supply chain agility; supply chain agility; scale development

INTRODUCTION

Agility has emerged as the dominant competitive vehicle for organizations operating in uncertain and ever-changing business environments, and has been heralded as the business paradigm of the 21st century (Tseng and Lin 2011). The concept has risen in significance as businesses no longer compete as solely autonomous entities, but rather as supply chains (Lambert and Cooper 2000; Christopher 2005; Defee and Stank 2005; Stank et al. 2005). Supply chain members must be capable of rapidly aligning their collective capabilities to respond to changes in demand and supply (Gligor and Holcomb 2012a). Furthermore, it has been recognized that to achieve a competitive advantage in the rapidly changing business environment, firms must align with suppliers and customers to coordinate operations and together achieve a level of agility beyond that of competitors (Lin et al. 2006). As supply chain agility has progressed from a conference topic to a practical imperative for most companies (White et al. 2005), agility has been highlighted as the fundamental characteristic of the “best” supply chains (Lee 2004).

Although agility has been identified as one of the most important issues of contemporary supply chain management (Lee 2004), the theoretical basis for understanding supply chain agility is fragmented (Li et al. 2008). Agility is a broad and multidimensional concept bridging many disciplines (Gligor and Holcomb 2012a). The multidimensionality of agility has led to much confusion and ambiguity (Giachetti et al. 2003; Li et al. 2009; Gligor and Holcomb 2012a). Elements and linkages among agility elements are underdeveloped, and it is uncommon for any two articles to adopt the same definition (Conboy 2009). A rigorously validated instrument to measure supply chain agility

is needed to enable researchers to credibly test explanatory theories regarding causal links among capabilities, practices, and performance outcomes related to this phenomenon (Sherehiy et al. 2007; Li et al. 2009).

This research addresses the gap related to the ambiguity surrounding the dimensions and definitions of firm supply chain agility by employing a multidisciplinary literature review to gain an in-depth understanding of agility. Specifically, the sports science and military science theoretical bases are investigated to better understand agility and identify its dimensions, and define it in a firm supply chain context. Furthermore, a comprehensive measurement instrument that draws on the foundations of social and life science theory is developed and empirically validated.

LITERATURE REVIEW

Scholars from multiple business disciplines have defined agility in ways that emphasized different aspects of the concept. Gligor and Holcomb (2012a) note that to date, many different definitions and characterizations of agility have appeared in the business literature. Through their comprehensive examination of the literature, the authors found that the definition and concept of agility is evolving. For example, much of the earlier research focused on agility as an ability that enabled firms to thrive in an environment of continuous and often unanticipated change (Gunasekaran 1998, 1999; Dove 1999; Sharifi and Zhang 1999; Sarkis 2001). More recently, Vinodh (2010) conceptualizes agility as a paradigm that facilitates companies to quickly respond to customers' dynamic demands. The concept, which initially concentrated on manufacturing, has expanded to become a wide-ranging response to a myriad of business challenges in a turbulent environment (Yauch 2011; Zhang 2011). Despite the evolution of the concept, inconsistencies in the multiple business definitions of agility have been further manifested in the existing supply chain research in its treatment of agility as a firm concept. As Gligor and Holcomb (2012a) indicate, few researchers

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provide a formal supply chain agility definition, and there is no agreement on the dimensionality of the concept (Li et al. 2008). For example, Swafford et al. (2006) define it as the capability to adapt or respond in a speedy manner to a changing marketplace environment, whereas Costantino et al. (2012) define it as a network of different companies integrated with streamlined material, information, and financial flow, and focused on flexibility and performance.

Swafford et al. (2006) approach supply chain agility as a uni-dimensional construct, while acknowledging its multidimensionality. Li et al. (2009) identify the *alertness to change* and the *response capability* dimensions. The resultant measurement instrument characterizes supply chain agility in terms of six factors: strategic alertness, strategic response capability, operational alertness, operational response capability, episodic alertness, and episodic response capability. One significant research limitation is the lack of detail on the composition of the *response capability*. An agile supply chain is described as being alert to changes and capable of responding to changes. However, no information is offered on how the response capability is developed or what that capability entails.

Braunscheidel and Suresh (2009) define firm supply chain agility as a second-order construct that is formed by the first-order dimensions of *demand response*, *joint planning*, *customer responsiveness*, and *visibility*. A significant weakness of this operationalization is the lack of theoretical rationale surrounding its development. No information is offered on how the four dimensions were identified.

The current research develops a comprehensive conceptualization and measurement scale of firm supply chain agility that explores the multidimensionality of the concept. Foundational social and life science theory identifies five firm supply chain agility dimensions, including alertness, accessibility, decisiveness, swiftness, and flexibility. The dimensions are used to define a firm's supply chain agility as *a firm's ability to quickly adjust tactics and operations within its supply chain to respond or adapt to changes, opportunities, or threats in its environment*. The following subsections present the literature review that lead to the emergence of the supply chain agility dimensions.

Alertness

Alertness, defined here as *the ability to quickly detect changes, opportunities, and threats*, emerged from a variety of domains both in foundational social and military science as well as in business. In sports science discipline, Sheppard and Young (2006) describe alertness as a rapid whole-body movement with change in velocity or direction in response to a stimulus, whereas Farrow et al. (2005) define agility as basic movements requiring the player to perform sudden changes in body direction. The ability of players to execute agility tasks is considered dependent on factors such as visual-scanning techniques, visual-scanning speed, visual processing, perception, and anticipation (Chelladurai 1976; Abernethy et al. 1999; Young et al. 2002; Sheppard and Young 2006). These factors are reflected in the players' on-field agility (Gore 2000). It has been suggested that elite performers differ from nonelite performers in their ability to anticipate the opponents' movements (Abernethy and Russell 1987). Some agility tests indicate that high-performance sports

players initiate a change in direction movement before the opponent's ball release due to anticipation of the other players' movements (Sheppard and Young 2006). Visual search and anticipation research have also shown that highly skilled athletes are able to successfully predict the action of an opponent before it is carried out (Bradshaw et al. 2010). The national protocol for the assessment of agility performance in team-sport athletes also recognizes the role of alertness and suggests that the athletes' ability to successfully use agility maneuvers in the actual game depends on factors such as visual processing, timing, reaction time, perception, and anticipation (Ellis et al. 2000).

Various conceptualizations of alertness have been introduced in military science. Dekker (1999) sees agility as the ability to perceive an upcoming threat and respond to it quickly, while the U.S. Army defines it more simply as the ability of friendly forces to act faster than the enemy (US Army 1997). It has been suggested that creating an agile military force requires speeding up the so-called OODA (observe, orient, decide, act) loop (Fewell and Hazen 2005). The concept of an OODA loop was developed by military strategist USAF Colonel John Boyd, and was originally applied at the operational and strategic levels in military combat operations. The alertness dimension of agility is captured within the *observe* and *orient* stages of the loop and is a prerequisite to an agile response. Some military science researchers refer to the alertness capability as situational awareness, and describe it as the perception of environmental elements with respect to time and space (Dekker 2006; Sheffer 2006). The speed of recognition of environmental elements is considered critical (Alberts 2007). In combat, military forces require early awareness of upcoming threats. The quicker changes are detected, the sooner the response can be deployed.

The dimension of alertness has also been a focus of business agility research. Sharifi and Zhang (1999) recognize that agile organizations need a basic ability that consists of sensing, perceiving, and anticipating changes in the business environment. Zhang and Sharifi (2000) divide agility capabilities into four major categories: responsiveness (ability to identify, respond to, and recover from changes quickly, reactively or proactively), competency (ability to efficiently and effectively realize enterprise objectives), flexibility/adaptability (ability to implement different processes and apply different facilities to achieve the same goals), and speed (ability to complete an activity as quickly as possible). Although it introduces some of the possible dimensions of agility, Zhang and Sharifi's (2000) conceptualization is problematic. One limitation of this conceptualization is the lack of distinction between the ability to detect changes and the ability to respond to changes. These two distinct capabilities are grouped under the *responsiveness* umbrella. This research expands on Zhang and Sharifi's (2000) work and posits alertness as a distinct dimension of agility. Other research articles also recognize the role of alertness in the design of agile manufacturing systems (Goldman et al. 1995; Almahamid et al. 2010; Inman et al. 2011; Vinodh and Prasanna 2011; Zhang 2011).

The role of alertness in achieving the desired level of agility is also emphasized within the information systems and information systems development research. Sarker and Sarker (2009) argue that agility lies in environmental scanning and sense-making routines for anticipating and recognizing possible or imminent crises, whereas other authors emphasize the important role of

sensing market opportunities and threats (Tallon and Pinsonneault 2011; Tseng and Lin 2011; Lu and Ramamurthy 2012). Within a supply chain management context, Christopher (2000) was the first to acknowledge that, to be truly agile, a supply chain must be capable of *reading* and *responding* to real demand. He refers to this capability as market sensitivity. One limitation of Christopher's (2000) interpretation is that although he recognizes the importance of *reading* customers' requirements, he does not conceptualize it as a distinct capability; he places it in the same category with the *responding* to real demand capability. Another drawback of Christopher's (2000) research is that it only recognizes the importance of reading demand information, with no reference to supply.

Other supply chain researchers also recognize that agility requires a timely awareness of change and adopt the market sensitivity dimension introduced by Christopher (Lin et al. 2006; Agarwal et al. 2007; Jain et al. 2008). However, it was Li et al. (2008) that first conceptualized alertness as a distinct dimension of supply chain agility. These authors argue that agile supply chains must be alert to changes, within the supply chain itself and within the surrounding environment. This dimension of agility manifests itself through sensing emerging market trends, listening to customers, and monitoring real demand through daily point-of-sale data (Li et al. 2008, 2009).

Accessibility

Accessibility emerged from the literature review as the second dimension of firm supply chain agility. It is defined in this study as *the ability to access relevant data*. Research suggests that once a change is detected through the alertness capability, firms must also be able to access relevant data to decide how to provide an agile response (Gunasekaran 1998; Sharp et al. 1999; Jain et al. 2008; Tseng and Lin 2011; Vinodh and Prasanna 2011; Lu and Ramamurthy 2012).

Supply chain-wide information access is recognized as a key requirement for supply chain agility (Vinodh and Prasanna 2011; Gligor and Holcomb 2012b). In his seminal article, Christopher (2000) argues that agile supply chains must possess a number of distinguishing characteristics. Agile supply chains must be *virtual*, that is, they must be information-based rather than inventory-based. Supply chain members must share real-time demand, inventory, and production information (Ahn et al. 2012). The creation of virtual supply chains allows all supply chain members to access relevant data and make informed decisions about how to respond to changes detected in the environment. Lin et al. (2006) refer to the capacity to access information as *information integration*, and describe it as the ability to use information technology to share data between buyers and suppliers. Information integration can be considered as the infrastructure needed to create a virtual supply chain (Christopher et al. 2004; Jain et al. 2008).

Manufacturing research also suggests that a requirement for designing agility is the creation of an environment where relevant information can be accessed. Goldman et al. (1995) consider the formation of virtual partnerships to be one of the four primary principles of agility. This perspective is supported by other manufacturing research articles that identify virtual enterprises, information technology, and communication as the key enablers of agility (Gunasekaran 1998; Sharp et al. 1999; Khalil

and Wang 2002; Cao and Dowlatabadi 2005; Eshlaghy et al. 2010; Zhang 2011; Costantino et al. 2012). Information systems and information systems development research also provide substantial empirical evidence for considering information integration as a key enabler of agility (Clark et al. 1997; Zaheer and Zaheer 1997; Gosain et al. 2005; Van Oosterhout et al. 2006; Mathiassen and Vainio 2007; Flink and Neumann 2007; Zhang and Sharifi 2007; Goodhue et al. 2009; Tseng and Lin 2011; Lu and Ramamurthy 2012). A high level of integration makes possible timely and accurate information gathering and sharing (Lu and Ramamurthy 2012). Real-time access to information allows supply chain members to quickly detect changes in customers' needs (Overby et al. 2006). Sheffer (2006) considers the ability to provide an agile response contingent upon effective information collection and dissemination. This perspective is also shared by Atkinson and Moffat (2005) who argue that information availability is a necessary condition for agility.

Decisiveness

Defined in this research as *the ability to make decisions resolutely*, *decisiveness* was identified as the third dimension of firm supply chain agility. Sports science and military science research suggest that agility is dependent on the ability to make resolute decisions using the available information. Motor learning researchers have recognized the role of decision making in agility tasks. They managed to isolate the decision-making time of players to evaluate its contribution to agility performance (Sheppard and Young 2006). Decision-making time is measured by the time elapsed between the moment a stimulus is presented to the player and the player's movement initiation (Bradshaw et al. 2010). Researchers control the alertness and accessibility aspects of agility by presenting the stimulus to the player (limited need for detection) and by offering the information on how to respond to the stimulus (limited need for information accessibility).

The impact of decision-making abilities on agility has been investigated across a variety of sports-related contexts (Chelladurai 1976). Helsen and Pauwels (1988) present expert and novice soccer players with a life-size film display of various tactically oriented patterns of soccer drills. The subjects were asked to physically respond to the footage when the ball appeared to be kicked toward them by shooting for goal, passing to a team mate, or dribbling past an opponent. The simulation revealed that expert players possess superior decision-making skills as compared with novice players. Research shows that superior performance in open-skilled sports is ultimately determined by effective decision-making skills (Abernethy 1991). Offensive players, who demonstrate proficient agility, employ superior decision-making skills in response to the movements and body positions of the opposing defenders (Sayers 2000). Wheeler and Sayers (2010) research of rugby players investigated the role of decision-making abilities when executing agility tasks. The authors concluded that decision-making drills must be incorporated in agility training programs (Wheeler and Sayers 2010). Their findings concur with other research that has shown that the inclusion of decision-making elements results in different levels of agility performance (Farrow et al. 2005; Sheppard and Young 2006; Bradshaw et al. 2010). Within Australian Rules football, decision-making skills were found to be the important agility

enablers as they help offensive players successfully evade opponents (Bradshaw et al. 2010).

In their definition of agility, Young et al. (2002) recognize that the two main components of agility are change in direction speed and decision-making factors. Other agility conceptualizations also acknowledge the contribution of decision-making abilities to agility performance in sports (Chelladurai 1976; Abernethy et al. 1999; Sheppard and Young 2006). Research also suggests that, as the complexity of the task increases, decision-making skills become more important (Sheppard and Young 2006). The increase in complexity affects an athlete's performance as evidenced by the weak correlation between straight sprinting ability and the ability to perform complex agility tasks (Tsitskarsis et al. 2003). The decision-making component of agility can help explain why straight sprinting performance (no decision making required) has little to do with agility performance. Previous research has observed less than 50% commonality between reactive (decision required) and preplanned (no decision required) agility performance (Farrow et al. 2005).

In a supply chain context, Christopher (2000) makes a clear distinction between speed (meeting customer demand through shortened delivery lead times) and agility (responding quickly to changes in demand in terms of both volume and variety). Military science research also recognizes the importance of decisiveness. The *decide* phase is one of the components of the OODA loop (Fewell and Hazen 2005). A three-step sequential process takes place during the *decide* phase: options generation, best option selection, and best option adaptation. Speeding up the *decide* phase is suggested to result in a more agile response (Dekker 2006).

The above literature review indicates that to develop supply chain agility, it is not enough to create the abilities to quickly detect changes (alertness) and access relevant information on how to deal with changes (accessibility). Firms must also foster the ability to make resolute decisions on how to respond to changes (decisiveness). Combined, the alertness, accessibility, and decisiveness dimensions of agility form the cognitive area of firm supply chain agility. These dimensions are related to information-processing and allow the firm to determine what actions to take in response to changes, opportunities, or threats.

Swiftness

Once a decision is made on how to respond to changes, entities must be able to quickly implement those decisions (Sharp et al. 1999; Gunasekaran and Yusuf 2002; Lin et al. 2006; Alberts 2007; Jain et al. 2008; Mackley et al. 2008). *Swiftness*, the fourth dimension of agility, is defined as the *ability to implement decisions quickly*. Sports and military science research recognize the enabling role of swiftness in fostering agility. Research on the effects of agility training on athletic power performance indicates that agility is highly dependent on the athlete's speed of movement (Sporis et al. 2010). Various sports agility tests have also identified change in direction speed as one of the pivotal components of agility (Young et al. 2002; Farrow et al. 2005). Although the terminology might vary across research articles (e.g., quickness, rapidness, swiftness, speed, velocity), a majority recognize swiftness as an essential component of agility (Clarke 1959; Mathews 1973; Draper and Lancaster 1985; Bloomfield

et al. 1994; Moreno 1995; Twist and Benicky 1996; Sayers 2000; Young et al. 2002; Tsitskarsis et al. 2003; Sheppard and Young 2006). Military science research also acknowledges swiftness by emphasizing the role of speed of movement (Dekker 2006) and speed of action (Alberts 2007; Mackley et al. 2008) in facilitating an agile response.

In business research, Christopher (2000) suggests that one of the required capabilities of agile supply chains is quickness, and defines it as the ability to complete an activity as quickly as possible. This ability is consistently recognized as a key enabler of agility across supply chain management research (Sharp et al. 1999; Lin et al. 2006; Jain et al. 2008). Swiftness is also captured within Li et al.'s (2008, 2009) *response capability* dimension of firm supply chain agility. Kumar and Motwani (1995) refer to the *swiftness* dimension of agility as the ability to accelerate activities on a critical path.

Manufacturing research provides additional support for considering swiftness a dimension of agility. Sharifi and Zhang (1999) argue that quickness is one of the necessary capabilities of an agile organization. They describe it as the ability to carry out tasks and operations in the shortest possible time. Kidd (1994) also recognizes that agile entities are fast moving, and Zhang (2011) considers quickness a characteristic of agile firms. In fact, agility as a business concept is centered around *speed* (Gunasekaran and Yusuf 2002). In one of the most frequently referenced articles on agile manufacturing, Gunasekaran (1998) identifies elements of swiftness (e.g., rapid partnership formation) as key agility enablers. A review of agility definitions (see Gligor and Holcomb 2012a) reveals that most conceptualizations of the construct place significant emphasis on *speed* (Iaccoca Institute 1991; Nagel and Dove 1991; Gehani 1995; Gupta and Mittal 1996; Quinn et al. 1997; Narasimhan et al. 2006; Eshlaghy et al. 2010; Zhang 2011).

Flexibility

The fifth dimension of supply chain agility, *flexibility*, is defined as the *ability to modify the range of tactics and operations to the extent needed*. Sports science researchers consider flexibility to be a key element of agility. In their research on agility training, Sporis et al. (2010) highlight the impact of flexibility on agility. Research shows that agility performance can be improved through flexibility training (Wong et al. 2011). Military science research provides additional support for considering flexibility as an important element of agility. This body of literature recognizes that built-in flexibility is needed for agile military response (McNaugher et al. 2000; Atkinson and Moffat 2005).

Business research also suggests that a firm's response to changes depends on the flexibility of its supply chain tactics and operations (Hong et al. 1996; Christopher and Towill 2002; Kumar and Deshmukh 2006; Safford et al. 2006; Safford et al. 2008; Eshlaghy et al. 2010; Jacobs et al. 2011; Costantino et al. 2012). In a sports context, the athlete's mobility of joints (i.e., flexibility) controls the range of quick adjustments the athlete can perform. The type of direction change (agility) performed will be dependent on the flexibility of the specific body parts involved in the exercise. Similarly, a firm's supply chain operates within a specific range, and the firm's supply chain agility (i.e., adjustment of tactics and operations) will be constrained by that

range. For example, the firm's supply chain cannot quickly produce more items than its fixed manufacturing capacity allows.

Supply chain agility literature recognizes the role of flexibility in providing an agile response. Empirical research found a direct positive relationship between procurement and manufacturing flexibility and supply chain agility (Swafford et al. 2006). In their framework, Swafford et al. (2006) consider supply chain agility as an externally focused capability that is derived from flexibility (internally focused competency) in supply chain processes. Research also indicates that supply chain flexibility directly and positively impacts supply chain agility (Swafford et al. 2008). Other supply chain researchers recognize the role of flexibility. In their definition of supply chain agility, Li et al. (2008, 2009) consider flexibility to be a core aspect of the construct. Similarly, this perspective finds support in a number of supply chain agility frameworks (Christopher 2000; Lin et al. 2006; Jain et al. 2008).

Flexibility has long been identified as a key agility dimension across manufacturing research. Agility as a business concept was first coined in relation to flexible manufacturing systems (Nagel and Dove 1991). The idea of manufacturing flexibility was subsequently extended into a wider business context, and the concept of agility as an organizational trait was born (Christopher and Towill 2002). The role of flexibility in providing an agile response is highlighted within several agility definitions. Hong et al. (1996) define agility as flexibility and rapid response to market demands, whereas Eshlaghy et al. (2010); describe it as a model that provides flexibility. In one of the most referenced frameworks of manufacturing agility, Sharifi and Zhang (1999) propose flexibility to be one of the capabilities that an agile organization must possess. This perspective is supported by a number of empirical research articles within the manufacturing realm (Yusuf et al. 1999; Gunasekaran and Yusuf 2002; Kumar and Deshmukh 2006; Eshlaghy et al. 2010; Jacobs et al. 2011; Costantino et al. 2012).

The firm supply chain agility construct

The examination of previous research also guided the classification of the agility dimensions into two higher echelon categories: physical and cognitive. Research suggests that swiftness and flexibility represent the physical dimensions of firm supply chain agility; alertness, accessibility, and decisiveness exemplify the cognitive dimensions of the concept. The cognitive dimensions of firm supply chain agility are related to information-processing and help firms to determine what actions to take, while the physical dimensions are related to action-taking and enable firms to implement those actions (see Table 1).

To clearly establish the relationship between supply chain agility and its dimensions, it is important to determine whether the supply chain agility construct is reflective or formative. Three theoretical considerations can help distinguish formative models from reflective ones (Coltman et al. 2008). The first theoretical criterion is the nature of the construct. In reflective models, the latent construct exists independent of the measures used, whereas in formative models, the latent construct is determined as a combination of its indicators (Rossiter 2002; Borsboom et al. 2003). The second theoretical consideration pertains to the direction of causality between items and the latent construct. In reflective

Table 1: Summary and classification of firm supply chain agility dimensions

Dimension	Definition	Type
Alertness	Ability to quickly detect changes, opportunities, and threats	Cognitive dimensions
Accessibility	Ability to access relevant data	
Decisiveness	Ability to make decisions resolutely	
Swiftness	Ability to implement decisions quickly	Physical dimensions
Flexibility	Ability to modify the range of tactics and operations to the extent needed	

models, variation in the construct causes variation in item measures, whereas in formative models, variation in item measures causes variation in the construct (Bollen and Kwok-Fai 2000; Edwards and Bagozzi 2000; Diamantopoulos and Siguaw 2006). The third theoretical criterion considers the characteristics of the items used to measure the construct. In reflective models, items are manifested by the construct and share a common theme. In formative models, items define the construct and need not share a common theme (Rossiter 2002; Jarvis et al. 2003). Based on these theoretical considerations and consistent with prior research (i.e., Li et al. 2009), firm supply chain agility is operationalized as a second-order reflective construct with the first-order factors of alertness, accessibility, decisiveness, swiftness, and flexibility (Figure 1).

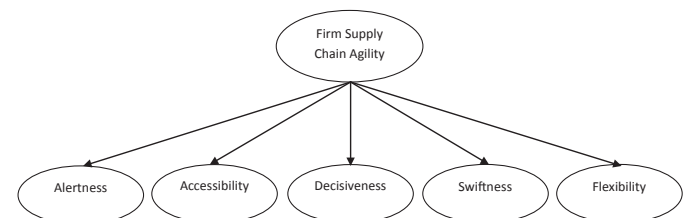
METHOD

Following the identification of the dimensions of supply chain agility, the next phase of the research was to develop and test scales for each of the factors. The procedures used to develop and assess the validity of the agility scale are described below.

Scale development and survey design

Scale development followed procedures and guidelines recommended by Churchill (1979), DeVellis (1991), Hinkin (1995), Mentzer and Flint (1997), and Garver and Mentzer (1999). Each dimension of the second-order construct is measured by multi-item scales to increase reliability, decrease measurement error, ensure greater variability among the survey participants, and improve

Figure 1: Dimensions of firm supply chain agility.



validity (Churchill 1979). Based on the literature review presented above, a pool of 33 items was generated to reflect each of the firm supply chain agility dimensions. To avoid scale proliferation, when possible, existing scales were consulted (Bruner 2003).

Once the survey items were determined, the procedures suggested by Dillman (2007) for survey design were employed. All variables of interest were estimated through respondents' perceptual evaluation on a 7-point Likert scale: the response categories for each item were anchored by 1 (strongly disagree) and 7 (strongly agree).

Pretests of the supply chain agility measurement scale

The scale items were pretested to increase reliability, decrease measurement error, and improve the validity of the construct measurement (Dillman 2007). A Q-sort method was employed to achieve these goals (Moore and Benbasat 1991; Li et al. 2009). The pretest was conducted in two stages: the first one was conducted with a sample of academics and the second with a sample of supply chain managers.

For the first phase of the pretest, a personalized email with a link to a Qualtrics-based Q-sort electronic document was sent to a group of 25 academic experts. The academic experts were selected based on their research interests, area of expertise, and industry experience. The document contained the survey items for the supply chain agility construct, along with the definition of each construct dimension. Respondents were asked to place each item under the dimension they felt best represented the item. Furthermore, the experts were asked to evaluate the items for face validity and provide qualitative feedback. Twenty responses were received, for an effective response rate of 80%. Based on the item placement ratios and the qualitative feedback received from academic experts, some survey items were revised, while others were selected for elimination. The purpose of the pilot test was to identify poor performing items rather than create highly purified scales (Defee et al. 2009).

Next, the resultant survey instrument was pretested using a random sample of supply chain managers drawn from a database of potential participants. The database of mid- and upper-level logistics, supply chain, and operations managers of North American companies was obtained from Dun & Bradstreet, a provider of business information. Potential respondents were carefully screened to ensure that they had relevant knowledge of their firms' supply chain operations. A similar procedure to the one employed during the first phase of pretesting was employed. A personalized email, with a link to a Qualtrics-based Q-sort electronic document, was sent to a sample of 272 managers. One-hundred responses were received, resulting in a response rate of 27.2%. The managers represented a wide array of industry sectors including manufacturing-general (16%), manufacturing-consumer products, transportation (15%), retail (9%), and 12 other sectors, which accounted for the remaining 40% of respondents. Annual sales for the respondents' companies ranged from less than \$250 million to greater than \$9 billion. The modal group was represented by companies with revenues of less than \$250 million (22%). Also, the level of professional work experience exceeded 20 years for 49% of the respondents.

The results of the second Q-sort pretest indicated that, except for four items, item placement ratios exceeded the recommended

level of .70 (Moore and Benbasat 1991), which was considered acceptable for exhibiting content validity, while the interjudge agreement exceeded the recommended .65 value (Perreault and Leigh 1989). Based on these results, and the qualitative feedback received from the managers, six survey items were revised and one was eliminated. Ultimately, six items were used to measure *alertness*, seven items to measure *accessibility*, six items to measure *decisiveness*, five items to measure *swiftness*, and six items to measure *flexibility*. These items were used for the final model testing.

Data collection and sampling for final model testing

The unit of analysis for the research is the firm, and the preferred target respondents were senior-level managers with knowledge of supply chain processes and activities, and direct involvement in operational and strategic decision making. Data were gathered using a nonexperimental survey methodology (Kerlinger and Lee 2000). Specifically, the research employed an Internet survey to collect the necessary data for model testing. The web-based survey approach is appropriate because the population of interest is business, and coverage issues are not present due to high rates of computer use and the large sample size (Dillman 2007).

Purposive sampling was employed in the hopes of achieving a moderate level of external validity and to contribute to the generalizability of results (Cook and Campbell 1979). Potential respondents were identified from two sources. The first source of potential participants was a database of supply chain managers that comprised the mailing list of the supply chain management program of a large public university. The database contained contact information for more than 3,000 managers (name, phone number, email, and title) from U.S.-based companies in a diverse set of industries. An email was sent to all contacts in the database requesting participation in the study. The Qualtrics software indicated that the email was received and opened by 285 respondents, confirming that correct/updated contact information existed for these managers. Therefore, this sample of 285 respondents was considered for final survey testing. To increase response rate, participants were offered an executive summary of the research findings and entered into a raffle for the chance to win \$100.

The second source of potential participants was selected from the panel members of SurveyMonkey, a large third party marketing firm that specializes in survey data collection. SurveyMonkey provided contact information for 1,135 senior-level managers of diverse backgrounds, with the knowledge of supply chain processes and activities, and direct involvement in operational and strategic decision making who were prequalified to participate in the study. Although participants were not provided any direct financial incentives, SurveyMonkey pledged to donate \$.50 to the charity of the respondents' choice, and enter the respondents into a raffle for the chance to win \$100.

Potential respondents from both databases (university supply chain program and SurveyMonkey) were prequalified using the procedures suggested by Dillman (2007) and Kerlinger and Lee (2000). Following the purification of the measurement instrument, the main survey test was sent to the sample of 285 potential respondents selected from the database of the university's supply chain program, and the sample of 1,135 prequalified

SurveyMonkey panel members. Two reminders spaced one week apart followed the initial email to the sample of university's supply chain members. Once all the data collection methods had been concluded, 141 usable responses were received from the sample of the university supply chain program contacts for a response rate of 49.5%. Five hundred and thirty usable responses were received from the SurveyMonkey panel members for a response rate of 46.7%. No reminder was sent to the SurveyMonkey panel members because of the initial high response rate. Responses from the two samples were compared using analysis of variance (ANOVA) and no significant differences were found. Combined, the two samples generated a total of 671 usable responses, which provided adequate statistical power to perform the necessary analysis. The demographics information for the final group of respondents is presented in Table 2.

For the survey sent to the sample of university supply chain program contacts, nonresponse bias was initially assessed by comparing first and second waves of survey responses using ANOVA (Armstrong and Overton 1977). Nonresponse bias was also examined using the guidelines suggested by Mentzer and Flint (1997). A random sample of 30 nonrespondents was contacted and asked to respond to five nondemographic questions. Specifically, the five questions addressed the construct of firm supply chain agility. A similar procedure was employed to test nonresponse bias for the SurveyMonkey panel members: a random sample of 30 nonrespondents was contacted and asked to respond to five nondemographic questions. For both samples (university supply chain program and SurveyMonkey panel members), no statistical difference was found between the answers to these questions of respondents and nonrespondents. Therefore, nonresponse bias is not considered a problem with the data.

Scale purification

Prior to purification of the measurement items, basic statistical analyses of the collected data were performed, such as examination of mean, minimum, and maximum values, standard deviation, and normality tests (i.e., skewness and kurtosis). The

primary approaches for measurement item purification included multiple iterations of confirmatory factor analysis (CFA), with the maximum likelihood estimation method that iteratively improves parameter estimates to minimize a specified fit function. In addition to the statistical analyses, theoretical assessment was made prior to final deletion of any measurement items. When modifying the model, indicators such as offending estimates, squared multiple correlations (SMCs), standardized residual covariances, and modification indices were considered. In the category of offending estimates, a check was performed for negative error terms, standardized coefficients exceeding or very close to 1.0, and very large standard errors. SMCs were reviewed as well to locate any relatively small SMC values that indicate that the portion of a variable's variance, that is accounted for by its predictor, is minimal at best (Joreskog and Sorbom 1989). Any SMC values of .20 or less were put to the test of deletion. Standardized residuals are the differences between the observed covariance and the estimated covariance matrix, and significant residuals (greater than |2.58|, which is statistically significant at the .05 level) indicate a substantial prediction error for a pair of indicators (Hair et al. 1998).

The modification index (MI) is a measure of whether an item loads on multiple factors. For the value of the MI, a coefficient value equal or greater than 3.85 indicates that chi-square can be statistically significantly reduced with the estimation of the coefficient. If a more conservative approach is taken, a value of MI equal to or greater than 10 would recommend an item for deletion (Fassinger 1987). The more conservative value of 10 was used for this research based on the assumption that most of the multiloading items had already been screened out in the pretest. Following the purification of the measurement instrument, all 30 items that were used to measure the dimensions of firm supply chain agility were retained including: six items used to measure *alertness*, seven items to measure *accessibility*, six items to measure *decisiveness*, five items to measure *swiftness*, and six items to measure *flexibility*.

Table 2: Demographics for the final test sample

Level of professional work experience	Percentage	Total company annual sales	Percentage	Type of industry	Percentage
<1 year	4	<\$250 million	18	Energy/Chemical/Mining	2
1–3 years	3	\$250 million–\$500 million	12	Communications/Media/Entertainment	3
3–5 years	10	\$500 million–\$1 billion	10	Retail	18
5–10 years	9	\$1–\$2 billion	17	Manufacturing-General	19
10–15 years	10	\$2–\$3 billion	13	Manufacturing-Consumer products	15
15–20 years	12	\$3–\$5 billion	10	Manufacturing-Aerospace/defense	4
20+ years	52	\$5–\$9 billion	8	Manufacturing-High technology	4
		>\$9 billion	12	Energy/Chemical/Mining	1
				Financial services/Insurance	2
				Life sciences-Pharmaceuticals	3
				Life sciences-Medical devices	3
				Health managed care	2
				Transportation service provider	8
				Other	16
Total	100		100		100

Analysis of scale measurement reliability and construct validity

Reliability was assessed using Cronbach's Coefficient Alpha, with a rule that an alpha above .70 indicates good correlation between the item and the true scores, and lower alpha levels suggest that the sample of items is a poor indicator of the construct (Churchill 1979). Also, because coefficient alpha tends to underestimate scale reliability and has several limitations, the guidelines suggested by Garver and Mentzer (1999) were followed as well. If the construct reliability measure is greater than .70 and the variance extracted is .50 or greater, then the support for reliability is adequate. Results in Table 3 indicate that for all dimensions coefficient alpha and construct reliability exceed the recommended value of .70; however, the variance extracted for the dimensions of *accessibility* and *flexibility* were at .487 and .475, respectively.

Construct validity was examined through the adequacy of the model's fit and both convergent validity and discriminant validity. Evaluating the overall model fit using the CFA technique is the first step in assessing construct validity. Goodness-of-fit criteria examine how well the data fit the proposed model. A model is considered to be satisfactory if the comparative fit index (CFI) is greater than .90, the goodness-of-fit index (GFI) is greater than .90, and the root mean square error of approximation (RMSEA) is less than .08 (Byrne 1998). Results indicate that the measurement model has a satisfactory fit with a chi-square of 1,941.194 and 400 degrees of freedom, CFI = .886, RMSEA = .077, and GFI = .803.

Convergent validity was judged by assessing the overall fit of the measurement model, the magnitude, direction, and statistical significance of the estimated parameters between the latent variables and their indicators, with .70 being the value of substantial

Table 3: Reliability and convergent validity results

Scale/Item	Cronbach Alpha for scale	Alpha if item deleted	CR	Item-to-total correlation	Mean	SD	Item loadings	Average variance extracted
Alertness								
A1	.899	.881	.898	.725	3.23	1.236	.761	.509
A2		.883		.714	2.97	1.169	.781	
A3		.878		.745	3.13	1.262	.791	
A4		.880		.729	3.04	1.234	.799	
A5		.879		.739	3.13	1.276	.773	
A6		.885		.701	3.26	1.237	.726	
Accessibility								
B1	.868	.851	.868	.625	2.95	1.168	.751	.487
B2		.843		.695	2.91	1.142	.785	
B3		.847		.658	3.15	1.346	.657	
B4		.843		.691	2.90	1.176	.780	
B5		.853		.619	3.19	1.358	.644	
B6		.847		.660	2.89	1.176	.668	
B7		.860		.561	2.83	1.272	.577	
Decisiveness								
C1	.868	.851	.880	.725	2.87	1.168	.786	.552
C2		.850		.729	2.96	1.208	.785	
C3		.846		.753	2.94	1.191	.805	
C4		.863		.654	2.85	1.219	.674	
C5		.870		.612	2.76	1.223	.665	
C6		.865		.639	3.06	1.185	.732	
Flexibility								
E1	.841	.808	.843	.654	2.93	1.273	.687	.475
E2		.802		.689	2.85	1.210	.772	
E3		.818		.606	2.71	1.291	.686	
E4		.832		.635	3.21	1.310	.637	
E5		.810		.647	2.59	1.164	.681	
E6		.820		.591	2.78	1.236	.665	
Swiftiness								
D1	.882	.861	.882	.700	3.08	1.276	.780	.598
D2		.850		.570	3.13	1.310	.788	
D3		.861		.522	3.23	1.274	.716	
D4		.852		.545	3.03	1.331	.790	
D5		.860		.509	2.95	1.244	.791	

Note: CR, construct reliability.

magnitude of the parameter estimate (Garver and Mentzer 1999). Results in Table 3 suggest that convergent validity is satisfactory. Convergent validity can further be assessed in terms of the degree to which the subscales are correlated. As shown in Table 4, the correlations between the dimensions are significantly different from zero ($p < .05$). This suggests that the five dimensions are all measuring some aspect of the same construct.

Discriminant validity was first assessed using the average variance extracted method (Fornell and Larcker 1981). The variance extracted measures for the five dimensions (alertness, accessibility, decisiveness, swiftness, and flexibility) were .509, .488, .552, .598, and .475, respectively. A check was performed to determine whether the average variance extracted for each pair of constructs was greater than their squared correlation. As Table 4 indicates, the dimensions are highly correlated, ranging from .868 to .994. Therefore, this test did not provide evidence of discriminant validity. Discriminant validity was further assessed by running a series of nested CFA model comparisons in which the covariance between each pair of constructs (one pair at a time) was constrained to one (Anderson and Gerbing 1982; Bagozzi and Yi 1988). If the chi-square difference test is significant when all of the correlations between the constructs are fixed to one for the theoretical model, and for the measurement model allowing the two constructs to correlate freely, then the constructs are deemed to discriminate adequately. Table 5 indicates that all constructs passed this test; however, this test was not considered sufficient to establish discriminant validity given the correlations among the constructs.

Due to a lack of satisfactory discriminant validity, the measurement items for each of the proposed dimensions were further refined using theoretical considerations. Specifically, each dimension was examined for nomological validity, which is a qualitative assessment of the tightness of the theory building and the definition of each construct (Bagozzi 1980; Mentzer and Flint 1997). To this end, a panel of five academic experts examined the definition of each construct and compared it to its assigned measurement items as a post hoc test to identify items that did most precisely fit the definition. Following this process, 14 of the 30 items for firm supply chain agility (FSCA) were retained. The final measurement items are presented in Appendix A, whereas the items selected for the elimination are presented in Appendix B. The model featuring the remaining items for the five dimensions of FSCA was then subjected to the discriminant validity procedures described above. The results of these tests continued to provide inadequate evidence of discriminant validity among the five dimensions. Therefore, the data provided insufficient evidence to model FSCA as a second-order construct reflecting five independent dimensions. As the five constructs

emerged as dimensions of FSCA, but not distinct from each other, FSCA was determined to be a first-order reflective construct tapping five domains of agility.

Final model results

Results of analysis of the measurement model portraying FSCA as a first-order construct indicate adequate fit with a chi-square of 481.102 and 77 degrees of freedom, CFI = .930, RMSEA = .090, and GFI = .897. Although it cannot be inferred that the five proposed FSCA dimensions are *distinct* from each other, the results suggest that in aggregate, the five concepts identified in the research represent domains of FSCA. The identification of the five dimensions of a firm's supply chain agility enables the development of a comprehensive definition as follows: *A firm's supply chain agility is manifested through the firm's cognitive and physical capabilities that enable the firm to quickly detect changes, opportunities, and threats (alertness), access relevant data (accessibility), make resolute decisions on how to act (decisiveness), quickly implement decisions (swiftness), and modify its range of supply chain tactics and operations to the extent needed to implement the firm's strategy (flexibility).*

RESULTS DISCUSSION

This research contributes to theory building by addressing the ambiguity surrounding the dimensions and definition of *firm supply chain agility*. It expands on Li et al. (2009) and Braunscheidel and Suresh's (2009) work by fully exploring the construct's multidimensionality. Alertness, accessibility, decisiveness, swiftness, and flexibility were examined as potential *firm supply chain agility* dimensions. Although the multidisciplinary literature reviewed indicated these constructs as potential dimensions of FSCA, the results of this research did not provide sufficient evidence to consider alertness, accessibility, decisiveness, swiftness, and flexibility as *distinct* dimensions of FSCA. The final measurement model displayed adequate convergent validity indicating that the suggested dimensions do capture the variance in the FSCA construct. However, the lack of satisfactory evidence of discriminant validity indicates that while these are indeed dimensions of FSCA, they might not be *distinct* from one another.

One plausible explanation of the lack of discriminant validity among the five FSCA dimensions can be found in the newly developed measurement items. Measurement items for four of the five dimensions used statements addressing the firm's response to changes, opportunities, and threats. For example, one item intended to measure *alertness* states "We can quickly detect

Table 4: Correlations table

	<u>Alertness</u>	<u>Accessibility</u>	<u>Decisiveness</u>	<u>Swiftness</u>	<u>Flexibility</u>
Alertness	1				
Accessibility	.920	1			
Decisiveness	.941	.922	1		
Swiftness	.985	.914	.994	1	
Flexibility	.868	.920	.923	.911	1

Table 5: Chi-square difference test to assess discriminant validity

	Accessibility	Decisiveness	Swiftness	Flexibility
Alertness (χ^2_{diff})	128.489	68.069	41.861	150.759
Accessibility (χ^2_{diff})		103.763	120.099	67.401
Decisiveness (χ^2_{diff})			25.03	80.68
Swiftness (χ^2_{diff})				129.996

Notes: $p < .001$; $df_{\text{diff}} = 4$.

changes in our environment,” whereas another used to measure *accessibility* reads “My company can access the information it needs to deal with *changes* in its environment.” In this example, the use of the word “changes” in both statements could have caused the high inter-item correlation, and therefore constitute a possible explanation of the lack of satisfactory discriminant validity among the suggested dimensions.

It can be concluded that future research is needed to further examine whether alertness, accessibility, decisiveness, swiftness, and flexibility are indeed *distinct* from one another. Identification of the 14 elements of FSCA did enable the development of a comprehensive definition to help address definitional inconsistencies associated with the construct and provide guidance for further theoretical testing of the concept. This is an important contribution as definitional ambiguities surrounding a concept pose a threat to its usefulness as a theoretical construct (Luthar et al. 2000). Another key contribution is the development of a comprehensive FSCA measurement instrument tapping the five dimensions.

Prior research has used the terms agility and flexibility interchangeably (Giachetti et al. 2003; Li et al. 2008; Almahamid et al. 2010), which makes theory building problematic. The confusion was in part generated by the fact that both terms were introduced as a means for organizations to deal with changes. Consistent with the literature reviewed in the previous sections, this research suggests that the two terms are distinct concepts, with flexibility being a dimension of agility. This differentiation was needed to gain a deeper understanding of agility and how the concept can be positioned against the backdrop of research addressing related business phenomena. For managers, the distinction illustrates the specific role each construct (i.e., agility and flexibility) has in assisting organizations to deal with changes.

Based on the sports and life sciences literature, this research posits that *firm supply chain agility* dimensions can be classified into two categories: cognitive and physical. The cognitive dimensions (alertness, accessibility, decisiveness) are related to information-processing, whereas the physical dimensions (swiftness, flexibility) are related to action-taking. For managers, the findings offer a clear distinction between the two types of capabilities that a firm must possess to achieve the desired supply chain agility level. Too often, the focus of managerial attention is on physical attributes of business initiatives at the expense of cognitive and behavioral dimensions.

Managers can use the comprehensive list of dimensions examined in this research to determine what aspects of their operations and tactics should be improved to enhance the firm’s supply chain agility. By evaluating their organization’s approaches to the five dimensions of supply chain agility, managers can identify aspects of supply chain management that need to be addressed to increase the firm’s supply chain agility. For instance, it could be the case that an organization excels at quickly identifying changes in its environment (i.e., alertness), but has suboptimal decision-making processes, which prevents it from making resolute decisions (i.e., decisiveness). Once managers identify weaknesses associated with either one of the five dimensions, corrective actions can be taken to reduce or eliminate these vulnerabilities, and increase the firm’s level of supply chain agility.

LIMITATIONS AND FUTURE RESEARCH

Limitations inherent to any single article can be addressed through future research. One plausible explanation of the lack of discriminant validity among the five FSCA dimensions could be due to the use of measurement items addressing the firm’s response to changes, opportunities, and threats for four of the five dimensions. Future research could help establish if eliminating those items from some of the dimensions would lead to the development of a five-dimensional measurement instrument with adequate discriminant validity. To establish statistical generalizability, the research presented in this article needs to be replicated with new samples from the population. A study can only address statistical generalizability by not drawing conclusions beyond the scope of its sample (Mentzer and Flint 1997). While this research sought generalizability across multiple industries, future research could focus on single industries.

The measurement instrument developed in this research should be tested in a nomological model of antecedents and outcomes, for instance, one examining strategic-level FSCA antecedents and performance-related outcomes. This would further validate the current research and increase the degree of confidence in the scale’s validity and reliability. Last, as is the case with most supply chain survey research, the constructs of interest were evaluated based on the perception of a single party involved in a specific supply chain. Future research using multiple dyads or triads within various supply chains could address this limitation.

APPENDIX A

FINAL SCALE ITEMS

-
- Firm Supply Chain Agility: Alertness
- A2 Our firm can promptly identify opportunities in its environment. (Adapted from Li et al. 2009)
- A3 My organization can rapidly sense threats in its environment. (Adapted from Li et al. 2009)
-

Continued.

- A4 We can quickly detect changes in our environment. (Adapted from Li et al. 2009)
Firm Supply Chain Agility: Accessibility
- B3 We always receive the information we demand from our suppliers. (Newly Developed)
- B5 We always obtain the information we request from our customers. (Newly Developed)
Firm Supply Chain Agility: Decisiveness
- C1 We can make definite decisions to address opportunities in our environment. (Newly Developed)
- C2 My organization can make firm decisions to respond to threats in its environment. (Newly Developed)
- C3 My company can make resolute decisions to deal with changes in its environment. (Newly Developed)
Firm Supply Chain Agility: Swiftiness
- D1 We can swiftly deal with threats in our environment. (Newly Developed)
- D4 My firm can quickly respond to changes in the business environment. (Newly Developed)
- D5 We can rapidly address opportunities in our environment. (Newly Developed)
Firm Supply Chain Agility: Flexibility
- E1 When needed, we can adjust our supply chain operations to the extent necessary to execute our decisions. (Newly Developed)
- E2 My firm can increase its short-term capacity as needed. (Adapted from Tachizawa and Gimenez 2010)
- E3 We can adjust the specification of orders as requested by our customers. (Adapted from Tachizawa and Gimenez 2010)

APPENDIX B

DELETED SCALE ITEMS

- Firm Supply Chain Agility: Alertness
- A1 We can notice changes in our environment quicker than our main competitors. (Newly Developed)
- A5 As compared with its main competitors, my company is faster to discover opportunities in its environment. (Newly Developed)
- A6 My company spots threats in its environment more rapidly than its main competitors. (Newly Developed)
Firm Supply Chain Agility: Accessibility
- B1 My firm can acquire the information it needs to respond to threats in its environment. (Newly Developed)
- B2 We can obtain the information we need to address opportunities in our environment. (Newly Developed)
- B4 My company can access the information it needs to deal with changes in its environment. (Newly Developed)
- B6 Our suppliers communicate relevant information to us. (Newly Developed)
- B7 Our customers share pertinent information with us. (Newly Developed)

Continued.

- Firm Supply Chain Agility: Decisiveness
- C4 Our supply chain managers are empowered to make decisions within their area of expertise. (Newly Developed)
- C5 In our firm, we have processes in place to facilitate decision making. (Newly Developed)
- C6 As compared with our competitors, my company is more resolute at making decisions regarding supply chain operations. (Newly Developed)
Firm Supply Chain Agility: Swiftiness
- D2 As compared with our competitors, my company is quicker at executing supply chain operations. (Newly Developed)
- D3 My company implements supply chain changes/decisions faster than its main competitors. (Newly Developed)
Firm Supply Chain Agility: Flexibility
- E4 We have a wider range of adjustments that we can make to our supply chain operations than our competitors. (Newly Developed)
- E5 My company can usually meet an increase in order-size. (Adapted from Tachizawa and Gimenez 2010)
- E6 Our firm can adjust/expedite its delivery lead times. (Adapted from Tachizawa and Gimenez 2010)

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Measurement and Moderation: Finding the Boundary Conditions in Logistics and Supply Chain Research

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A moderator is any variable that affects the strength of a relationship between a predictor and an outcome variable. While simple in concept, the application of moderation analysis can yield profound implications to research conducted in logistics and supply chain management. Moderation analysis illuminates boundary conditions to purported relationships, providing a deeper perspective on what may, to date, represent generalizable findings and commonly held beliefs in the field. Such findings prove interesting and enrich our theories. Further, moderation relies on precise measurement of theoretical constructs in order to avoid attenuation of statistical tests and detect interaction effects. This thought leadership piece seeks to: (1) assert the value of moderation analysis and encourage a more prominent place in our survey-based research projects, (2) provide best practice approaches for using this type of analysis in pursuit of greater depth and clarity in our research, and (3) provide seeds for potential research projects that could benefit from the use of this type of analysis. Guidance is also provided for reviewers who assess manuscripts featuring moderation.

Keywords: moderation analysis; interactions; empirical methods; measurement; boundary conditions

INTRODUCTION

As the logistics and supply chain management (SCM) disciplines mature, increased emphasis will be placed on establishing the boundary conditions of our theories through moderation analysis (Fawcett and Waller 2011). Identifying limits and boundary conditions improves the precision of our theorizing (Edwards and Berry 2010), increases the validity of our findings (Leavitt et al. 2010), and helps ensure that we utilize nontautological theories given that all falsifiable theories must have their limits (Popper 1959; Gray and Cooper 2010). Hall and Rosenthal (1991) assert that “if we want to know how well we are doing in the biological, psychological, and social sciences, an index that will serve us well is how far we have advanced in our understanding of the moderator variables of our field” (p. 447). Simply stated, the exclusion of important moderator variables can lead to overgeneralizations that fail to illuminate the boundary conditions under which purported relationships exist.

In order to leverage moderation analysis effectively, it is critical to understand the connection between moderation and measurement of our theoretical constructs. Moderation and measurement are tightly intertwined in that (a) measurement error can result in extreme attenuation of statistical tests for moderation when regression approaches are used (Aiken and West 1991) and (b) common method variance (CMV) severely deflates interaction effects (Siemsen et al. 2010). In addition to illustrating how intimately moderation analysis is linked with measurement, the objectives of this article are: (1) to assert the value of moderation analysis and encourage a more prominent place in our disciplines’ survey-based research projects, (2) to provide best practice approaches for using this type of analysis in pursuit

of greater depth and clarity in our research, and (3) to provide some seeds for potential research projects that could benefit from the use of this type of analysis.

MODERATION 101

A *moderator* is any variable that affects the strength of a relationship between a predictor and an outcome variable. Imagine one is looking at how a certain logistics practice influences firm performance. In many instances, it is likely that extant theory provides a logical rationale for why at least one variable, such as the level of industry competition or characteristics of the products being sold, should affect the strength and/or direction of the relationship between the focal logistics practice and firm performance. In fact, some moderator variables may even lead to an observed negative effect of the investigated logistics practices on performance. Identifying such boundary conditions provides a deeper perspective of the focal relationship and enriches our theories (Fawcett and Waller 2011), and it helps researchers evaluate the robustness of their results (Maloni and Carter 2006; Goldsby and Autry 2011). As noted by Leavitt et al. (2010) “by predicting interaction¹ effects...our confidence in a theory...is bolstered” (p. 660). It is this deeper perspective that we, as researchers, should be striving to provide to our constituents (Knemeyer and Naylor 2011). Furthermore, moderation analysis allows researchers to discover unanticipated contingencies between variables, which can challenge commonly held beliefs, one example of what Davis (1971) terms “interesting” research

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¹“Moderation” and “interaction” can be treated as synonyms given that theorizing why the moderator variable changes the strength and/or direction of the focal variable’s relationship with the outcome implies that an interaction exists between the focal predictor and moderator.

that can fundamentally alter how a field views certain phenomena.

To provide an example, consider the findings from Cahill et al. (2010), who examine (1) the effects of three facets of logistics customer service (service, cost, and relational performance) on customer loyalty in logistics service provider–customer arrangements, and (2) whether the hypothesized relationships are moderated by conflict frequency. Their work suggests that the effect of these different facets of logistics customer service on customer loyalty is contingent on the conflict frequency. They find that when conflict frequency is low, satisfaction with operational aspects of logistics service is the dominant driver of customer loyalty; when conflict frequency is high, satisfaction with relational aspects of logistics service is the dominant driver of customer loyalty.

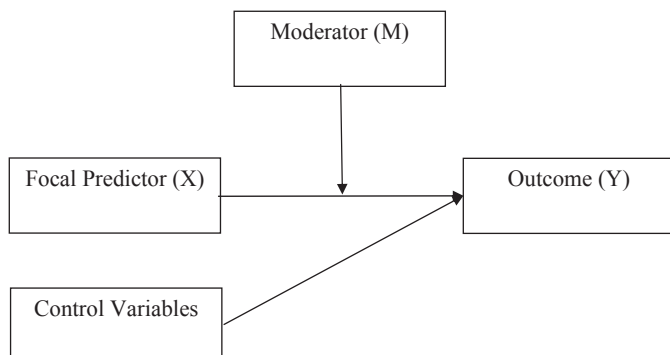
Furthermore, while moderation analysis has been used more often in recent publications, only a few articles position moderation as a central point of attention (e.g., Flynn et al. 2010; Zsidisin and Wagner 2010), even though from a theoretical and statistical standpoint the moderated effect is the center of attention. Thus, it is necessary not only to make the moderation a more focal point of argumentation, but also to change how we have traditionally theorized moderated relationships, consistent with Edwards and Berry's (2010) call to increase the precision of theorizing in the organization sciences.

Connecting the theory and the mathematics of moderation

A common practice among social scientists is to hypothesize a linear effect between a predictor of interest and an outcome variable before introducing the moderator—to theorize why this variable should influence the strength of the relationship between the predictor and the outcome. However, such an approach is inconsistent with the theoretical meaning of moderation and likely has resulted in many misconceptions about moderation analysis.

As a basis to understand why such an approach is theoretically inconsistent, we begin by briefly reviewing moderation analysis. Figure 1 represents a simple two-way moderation model where variable X is the focal predictor of interest, Y is the outcome variable, and M is the variable expected to moderate the relationship between X and Y . Including control variables, the conceptual model can be visually represented as depicted in Figure 1.

Figure 1: Basic moderation model.



Assuming the control variables, K_1 – K_w , the model would be represented using the following linear equation adapted from Hayes and Matthes (2009):

$$Y = i + \beta_1 X + \beta_2 M + \beta_3 XM + \sum_{j=1}^w \beta_j K_j + \varepsilon. \quad (1)$$

In Equation (1), assuming unstandardized coefficients, i represents the regression intercept; β_1 , called a first-order effect, represents the change in Y due to a one-unit increase in X when M equals zero; β_2 represents the change in Y due to a one-unit increase in M when X equals zero; and β_3 represents the change in the slope of X on Y due to a one-unit increase of M or, equivalently, the change in the slope of M on Y due to a one-unit increase of X (Hayes and Matthes 2009; Hayes et al. 2012).² Moderation is present when β_3 is significantly different from zero.

The effect of X on Y , termed simple slope by Aiken and West and denoted as θ_X , can be calculated as the first partial derivative of Y with respect to X . This is shown in Equation (2):³

$$\theta_X = \frac{\partial Y}{\partial X} = \beta_1 + \beta_3 M. \quad (2)$$

A key interpretational point from Equation (2) is that when moderation is modeled via product terms using regression approaches, the model *does not*—as often believed—contain a “main effect.” Rather, β_1 captures the conditional effect of X on Y when M is zero (Irwin and McClelland 2001; Hayes and Matthes 2009).⁴

When conducting moderation analysis with a categorical moderator using multigroup structural equation modeling (SEM), it is also best to think in terms of conditional effects. Here, a categorical moderator is utilized to split the data into two (or more) groups. The key difference is that in multigroup analysis the interpretation of a moderated relationship becomes “in group one, a one-unit increase in X results in a certain change in Y , whereas in group two a one-unit increase in X results in a certain (possibly different) change in Y .” Moderation is considered present when the $\Delta\chi^2$ test from constraining the structural pathways to equality between the two groups is significant compared to a

²In all cases the control variables are assumed to be held constant.

³An important assumption to arrive at Equation (2) is that X has not been previously transformed by a nonlinear function, as is often done with sales and revenue data through logarithmic transformations. See Hayes and Preacher (2010) for several examples and interpretational challenges due to the added complexity of the partial derivative.

⁴It should be noted that this is distinct from the analysis of variance (ANOVA) framework, where main effects are present because the independent variables are treated as orthogonal. However, it should be noted that while there are main effects in ANOVA, when a significant interaction is found it is recommended that “simple effects” of one factor at a fixed level of the second factor be tested (Keppel and Wickens 2004), which is equivalent to testing the significance of the conditional effect of X on Y at a given level of M , as captured in Equation (2).

model where the structural pathways are freely estimated⁵ (Byrne 2009).

CONDUCTING MODERATION: FROM THEORY TO EXECUTION

Given the importance that moderation analysis has played—and will increasingly play—in advancing research, we summarize a state-of-the-art method for conducting moderation analysis from theorizing to testing and interpreting results. This guidance is presented in Table 1 and explained in sequence below. For the sake of simplicity and illustration purposes, this discussion assumes the study of one moderating variable at a time. Three-way interactions, which denote that the conditional effect of X at a specified value of M changes depending on the level of a third moderator (Z), require more complex analytical and theoretical treatment than the effects discussed here (Aiken and West 1991). Similarly, we do not examine scenarios with curvilinear and interaction effects, but focus on most commonly observed interpretational and reporting challenges that have been noted in the literature (Irwin and McClelland 2001; Hayes et al. 2012). More details about these recommendations can also be found in Aguinis and Gottfredson's (2010) primer on moderated multiple regression for testing moderation.

Theorizing moderated relationships

In Equation (2), the presence of moderation means that the slope of X on Y is conditional on the value of M . As such, the procedure of first theorizing a linear effect of X on Y and only thereafter theorizing an interaction effect is inconsistent with one's initial expectations because the researcher ultimately expects that the effect of X on Y is conditional on M . In other words, how can something be constant but then vary based on the level of another variable? Rather, the researcher should utilize theory and past empirical findings to sketch logical arguments for the sign of the interaction effect (β_3). Once the researcher has done this, contingent hypotheses such as theorizing that X will have a positive impact on Y when M is low but have a negative impact on Y when M is high may be developed.⁶ This is consistent with both Bagozzi (2011), who notes that theoretical rationales should be expressed contingently, and Edwards and Berry's (2010) call for the development of contingent predictions to increase the precision of theorizing in the organization sciences.

⁵Assuming two groups, an equivalent test would be to conduct a Z-test to determine whether the difference between freely estimated structural pathways in both groups was different from zero using formulas from Cohen et al. (2003). With one moderated pathway, these tests are equivalent and the analyst would find that if the value from the Z-test was squared, this would equal the value for the $\Delta\chi^2$ test with $df = 1$.

⁶We wish to stress that developing contingent hypotheses is not required; the important hypothesis is the direction of the interaction effect (i.e., positive or negative).

Data collection: the importance of highly reliable measures

As outlined at the start of this piece, moderation analysis and measurement are intimately linked. Standard moderation analysis conducted using multiplicative regression approaches does not account for attenuation due to measurement error of the predictor and of the moderator. This link can be explicitly seen in Equation (3)⁷ from Busemeyer and Jones (1983).⁸

$$\rho_{XM, XM} = \frac{\rho_{XM}^2 + \rho_{XX}\rho_{MM}}{\rho_{XM}^2 + 1}. \quad (3)$$

In Equation (3) if the correlation between X and M is zero, the reliability of XM is the product of the reliabilities of X and M , and as the correlation between X and M increases, the reliability of XM approaches the reliability of the constituent terms. In Table 2, we illustrate the reliability of the product term of X and M given varying levels of ρ_{XM} , ρ_{XX} , and ρ_{MM} .

Table 2 illustrates an important challenge that researchers face when undertaking moderation analysis in the presence of measurement error. In most realistic situations, the reliability of the product term is severely attenuated, which greatly reduces the probability that the researcher will detect a statistically significant interaction effect (Aiken and West 1991). It should be noted that the degree of attenuation is not linear and is more severe when X and M have lower reliabilities. For example, assuming uncorrelated X and M and each having a reliability of 0.70, then the reliability of XM is 30% lower (0.49), but when X and M have a reliability of 0.90, then the reliability of XM is only 10% less (0.81). Given that interaction effects in nonexperimental research often only have small effect sizes (Cohen 1988), researchers benefit from the use of highly reliable scales to help minimize any further attenuation.

Conducting the analysis

Dalal and Zickar (2012) note that one of the most persistent “urban legends” about moderation analysis concerns mean-centering or standardization of the focal predictor and moderator before calculating the product term. Mean-centering or standardization is *not* necessary as analytically demonstrated by Echambadi and Hess (2007) and does not impact the statistical power to detect interaction effects (Hayes and Matthes 2009; Dalal and Zickar 2012). It is also essential to include the constituent (first-order) terms that form the product term in the model for statistical reasons discussed in detail by Aiken and West (1991) and Irwin and McClelland (2001).⁹

⁷ $\rho_{XM, XM}$ is the reliability of the product of X and M ; ρ_{XM} is the correlation between X and M , ρ_{XX} is the reliability of X ; and ρ_{MM} is the reliability of M .

⁸This equation is based on the assumption of bivariate normality and of the means of X and M to be zero.

⁹Additional standard assumptions such as (1) residuals following a normal distribution, (2) homoskedasticity of the residuals, (3) no correlation between the exogenous variables and the residuals due to omitted variables, and (4) independence of the residuals should also be met for conducting the analysis (Cohen et al. 2003).

Table 1: Guidance for conducting moderation analysis

Analytical techniques	OLS regression Logistics regression Hierarchical linear model	Multigroup structural equation modeling
	Nonlinear structural equation modeling	
Type of moderator	Nominal categorical, ordered categorical, interval, or ratio	Nominal categorical, ordered categorical, may not be interval or ratio
Theorizing moderation hypotheses	Do not theorize “main effects” then the interaction; rather, utilize theory to develop a hypothesis for the interaction effect to provide a theoretical explanation for why the strength and/or direction of X to Y should change If developing hypotheses for the effect of the focal predictor at different levels of the moderator (i.e., positive when M is high, negative when M is low), be sure to state these hypotheses as conditional effects	Do not theorize “main effects” then the interaction; rather, utilize theory to develop a hypothesis for the interaction effect to provide a theoretical explanation for why the strength and/or direction of X to Y should change If developing hypotheses for the effect of the focal predictor at different levels of the moderator (i.e., positive for group one but negative for group two), be sure to state these hypotheses as conditional effects
Testing moderation hypotheses	Describe any data transformations prior to forming the interaction terms if X and/or M are interval or ratio Unstandardized X and M with no mean centering Unstandardized X and M with mean centering Standardized X and M Utilize the “step-down” approach of including scale invariant interaction term; if the scale invariant term is not significant, remove from model and rerun analysis Moderation is present if interaction effect is significant.	First establish configural and metric invariance using multigroup analysis Utilize ΔCFI , ΔRMSEA , and ΔSRMR guidelines developed by Chen (2007) to establish configural and metric invariance Test moderation hypotheses using $\Delta\chi^2$ test comparing the fit of the model with the focal predictor freely estimated and constrained to equality across the groups Moderation present if significant $\Delta\chi^2$ when comparing the fit of the model with the equality constraint of the focal predictor
Interpretation and presentation of results (assuming the interaction is significant)	Report unstandardized coefficients If X and M were standardized before forming the product term, the unstandardized coefficients will represent a standardized effect If the moderator is dichotomous, plot the predicted value of the outcome variable across the range of X at both levels of M If the moderator is continuous, develop a Johnson–Neyman plot illustrating the region of significance for the simple slope	Report unstandardized coefficients Reporting standardized coefficients requires demonstrating that variances of the latent variables are invariant before comparing standardized coefficients across groups has meaning Plotting the interaction effect is unnecessary

If conducting multigroup SEM, a researcher completes the test of a significant interaction via a $\Delta\chi^2$ test for the multigroup model with the hypothesized moderated pathway freely estimated and constrained across the groups. Prior to conducting this test, the researcher should establish configural and factorial invariance (Vandenberg and Lance 2000). Briefly, configural invariance refers to establishing that the same pattern of fixed and free loadings that approximately recreate the covariance matrixes for both groups, whereas factorial invariance (also termed “weak metric

invariance”) refers to establishing that the factor loadings operate similarly across the groups (Marsh et al. 2009). We suggest using Chen’s (2007) guidelines for changes in comparative fit index (CFI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR), an approach also advocated by Byrne (2009) and Marsh et al. (2009) to establish configural and factorial invariance. Importantly, as noted by Newsom et al. (2003), researchers should not conclude that moderation is present just because the structural

Table 2: Calculations of the reliabilities of the product term XM contingent on the reliabilities of X and M when ρ_{XM} is 0 (panel A), 0.25 (panel B), and 0.50 (panel C)

		Reliability of M			
		0.6	0.7	0.8	0.9
Panel A: $\rho_{XM} = 0$					
Reliability of X	0.6	0.36	0.42	0.48	0.54
	0.7	0.42	0.49	0.56	0.63
	0.8	0.48	0.56	0.64	0.72
	0.9	0.54	0.63	0.72	0.81
Panel B: $\rho_{XM} = 0.25$					
Reliability of X	0.6	0.40	0.45	0.51	0.57
	0.7	0.45	0.52	0.59	0.65
	0.8	0.51	0.59	0.66	0.74
	0.9	0.57	0.65	0.74	0.82
Panel C: $\rho_{XM} = 0.50$					
Reliability of X	0.6	0.49	0.54	0.58	0.63
	0.7	0.54	0.59	0.65	0.70
	0.8	0.58	0.65	0.71	0.78
	0.9	0.63	0.70	0.78	0.85

pathway is significant in one group and not significant in another.

Reporting results

When testing interactions between variables in the form of product terms, researchers must report the scales of X , M , and XM (i.e., raw or standardized), as this impacts the interpretation of the coefficients (Hayes and Matthes 2009; Dalal and Zickar 2012). If XM is created using raw or mean-centered data in the original unit metric, then “standardized” effects should *not* be reported because they lack an interpretable statistical meaning¹⁰ (Aiken and West 1991). To aid in understanding the interaction, we encourage the reporting of interaction plots consistent with Aiken and West (1991). When the moderator is a dichotomous variable, we recommend plotting the predicted values of the dependent variable across the range of the focal predictor at the two values of the moderator. When the moderator is a continuous variable, we recommend developing a Johnson–Neyman graph of the region of significance for the simple slope of the focal predictor across the range of the moderator (Bauer and Curran 2005). Such plots can easily be created using online tools available from Preacher et al. (2006), or using macros developed by Hayes and Matthes (2009).¹¹ We prefer the Johnson–Neyman technique when the moderator is continuous because (1) exact values for when the

simple slope of the focal predictor differs from zero are calculated, and (2) the range of the confidence bands for the simple slope indicates the precision of its point estimate (Bauer and Curran 2005; Miller et al. 2013).

In conducting multigroup analysis, plotting the interaction effect is not necessary given the interpretability of the structural coefficients across groups. However, it is important that unstandardized effects be reported for multigroup analysis. For example, imagine that in groups one and two the standardized effect of $X \rightarrow Y$ is 0.25, but in group one the standard deviation of X is 2 units and the standard deviation of Y is 4 units, while in group two the values are 2 and 2, respectively. In such a scenario, the unstandardized effect in group one is 0.50, and the unstandardized effect in group two is only 0.25. Kim and Mueller (1976) and Newsom et al. (2003) provide a discussion of this issue in greater detail, but this simple numerical example demonstrates that reporting standardized coefficients when the variances of X and Y are different across levels of M can be problematic.

Given the complexity of moderation analysis and the potential unfamiliarity of reviewers with how to evaluate such analyses, we provide a set of guidelines in Table 3 helpful for reviewers who assess manuscripts featuring moderation. Here, too, we assume that a single moderator is present in each hypothesized relationship.

Additional benefits of moderation analysis

In the measurement domain, identifying significant interaction effects provides evidence that a researcher likely suffers from minimal contamination due to CMV given that CMV can only attenuate interaction effects (Evans 1985; Siemsen et al. 2010). Simulation research by Evans (1985) and subsequent analytical analysis by Siemsen et al. (2010) find that CMV stemming from a single unmeasured method factor *cannot* inflate the parameter estimate of an interaction. Rather, CMV can heavily *deflate* these estimates, and Siemsen et al. (2010) note that under realistic conditions deflation of 255% could be expected. Two implications stem from these findings. First, researchers must be cognizant of the deflation of interaction terms from CMV and design their surveys following guidelines proposed by Podsakoff et al. (2003) and Rindfleisch et al. (2008) in order to minimize these concerns for deflation. Second, given that simulation studies by Richardson et al. (2009) and Chin et al. (2012) recommend that common approaches for testing for CMV, particularly the use of an unmeasured, uncorrelated latent method factor, be discontinued, moderation analysis may represent one of the best, albeit indirect, approaches to evaluate concerns about CMV biasing findings.

PUTTING MODERATION TO WORK

To provide direction for future research utilizing moderation analysis, we provide several examples of commonly researched relationships in logistics and SCM in Table 4. Here, we introduce a theoretically motivated moderating variable for the relationship and an explanation of the prospective benefit for testing such an effect. By these means, the researcher can explore the boundary conditions of established knowledge.

¹⁰“Standardized” effects are calculated by multiplying an unstandardized effect by the ratio of the standard deviation of the predictor over the standard deviation of the dependent variable. This is problematic in the context of moderation analysis because it ruins the interpretation of the coefficients as interpreted in Equation (1).

¹¹Excel-based tools are also available from the third author upon request.

Table 3: Guidance for reviewers

Stage	Questions to ask
Theorizing	Have the authors developed a logically consistent series of arguments predicting the sign of the interaction effect (i.e., positive or negative)? Have hypotheses predicting the effect of <i>X</i> on <i>Y</i> been developed as conditional effects given the authors have theorized an interaction?
Testing	Have the authors reported whether <i>X</i> , <i>M</i> , and <i>XM</i> are in their raw unit score, mean-centered unit score, or standardized scores? Have the authors included all constituent (lower-order) terms necessary for testing the interaction? If conducting multigroup SEM analysis, have the authors established configural and factorial invariance prior to testing the invariance of the structural pathway?
Interpretation and presentation	Have the authors reported “unstandardized” effects, as “standardized” effects <i>should not</i> be reported since these lack interpretational meaning? Have the authors interpreted the results properly, such as avoiding statements of “main effects”? Have the authors provided a visual representation of the interaction, especially when using product terms, to aid the audience in interpreting the interaction?

Table 4: Prospective moderation analysis in logistics and supply chain management

Focal Predictor	Outcome variable	Potential new moderator	Benefits from empirical testing
Customer satisfaction	Customer loyalty	Customer satisfaction (curvilinear)	Identify if a “threshold” effect exists, whereby a minimum level of satisfaction is needed to maintain the level of loyalty
Trust	Commitment	Behavioral uncertainty	Examine if trust plays a more powerful role in influencing commitment when it is more difficult for a customer to monitor a supplier’s outcomes and procedures
Information technology usage for exploitation	Collaboration	Environmental dynamism	Examine if the effectiveness of using information technology is contingent upon different information processing requirements (i.e., highly equivocal information)
Logistics customer service	Customer satisfaction	Demand uncertainty	Identify if customers with different demand patterns place more (or less) emphasis on various dimensions of logistics customer service
Supplier integration	Performance	Supplier integration (curvilinear)	Better examine if “plateau” effects occur whereby additional integration returns no performance gains or, potentially, diminishes performance
Supply chain collaboration	Relationship outcomes	Transaction-specific investments	Determine the thresholds under which transaction-specific investments influence relationship outcomes, like satisfaction, switching behavior, extensions, and referrals

It should be noted in Table 4 that two proposed relationships are expected to be quadratic effects, which can be thought of as a situation where the focal predictor moderates its own relationship with the outcome variable because the impact of an increase of the focal predictor on the outcome is contingent on the current value of the focal predictor (Aiken and West 1991; Hayes and Preacher 2010). For example, adopting the lens of expectation-disconfirmation (Oliver 1980; Mittal et al. 1998), one would expect that the relationship between customer satisfaction and

customer loyalty would exhibit a negative quadratic relationship. If customer satisfaction was low, then an increase in customer satisfaction would be expected to result in a substantial increase in customer loyalty (implying a positive simple slope). However, once customer satisfaction crosses a given threshold, one would expect that the same increase in customer satisfaction would have minimal impact on improving customer loyalty. Guidance for interpretation of these relationships is found in Kelava et al. (2011) and Hayes et al. (2012).

FINAL THOUGHTS

As the logistics and SCM disciplines mature, moderation analysis will become an increasingly important analytical approach to establish the boundary conditions of our theories. Developing and testing moderated relationships will increase the precision of our theorizing (Edwards and Berry 2010) and allow us to make more informed recommendations to our practitioner audience. Furthermore, establishing boundary conditions to our theories will allow us to begin to “prune” the increasingly dense theoretical landscape in the best tradition of Platt’s (1964) call for *strong inference* by focusing our research efforts on theories that prove robust to falsification (Leavitt et al. 2010). However, conducting such analyses requires researchers to develop highly reliable measurement instruments and data collection protocols that will minimize the concern of CMV given that both measurement-related issues can severely attenuate these effects. It is our hope that this thought piece will help clarify any misconceptions concerning moderation analysis and provide researchers in our disciplines with guidance for testing these effects in the hopes of finding “interesting” results (Davis 1971).

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Conceptualizations of Trust: Can We Trust Them?

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Although logistics and supply chain management research efforts have continued to become more sophisticated, opportunities still exist for further advancement. One critical area needing improvement is enhanced scale development and validation. This study provides insights into the strengths and weaknesses of one specific construct, trust, by examining how trust has been measured in our literature. A methodology for improving scale development, the Q-sort procedure, is used to demonstrate a need for better measurement scales. Our findings suggest that numerous measures of trust have been used for logistics and supply chain research—most of which have been borrowed from other disciplines—without significant replication. More importantly, the results illustrate that all too often content validity is less than adequate. It appears as though we are not always measuring what we want to. Greater focus is recommended for future research that examines theory-based scale development, purification of measures, and replication of scales to further refine and improve construct measurement for enhanced survey research.

Keywords: Q-sort; scale development; scale validity; trust

INTRODUCTION

Logistics/supply chain management (SCM) research has evolved significantly since the first issue of the *Journal of Business Logistics* appeared in 1978. As an example of this evolution, Georgi et al. (2010) summarize how the intellectual foundation of the journal has changed since its inception, shifting from predominantly operationally focused research to more strategic-oriented research. Perhaps much of this evolution is a result of, or was at least partially motivated by, calls from within the field for more rigorous theoretical and methodological focus. For example, Stock (1990, 1996, 2002) calls for the logistics discipline to broaden its perspectives on logistics and its role within the corporate landscape by not only delving into research in nontraditional areas but also including other disciplinary approaches, such as psychology and organizational behavior, in our research. In 1994, Dunn et al. discuss the need for greater scale development and validation in logistics research as the field was embarking on research that involved more latent variables. Scale development and validation was critical to move logistics research from purely descriptive to a more theoretically driven approach (Dunn et al. 1994). Furthermore, as research in logistics began focusing on more behavioral approaches, scale development and validation were considered more critical for advancing logistics theory (Keller et al. 2002).

Despite such evolution, recent research has indicated that more work is needed. Sanders and Wagner (2011) propose that “multi-disciplinary and/or multimethod research can provide greater insight into today’s and tomorrow’s challenges and opportunities” (p. 317). In addition, Goldsby and Autry (2011, 324) suggest “despite the acceleration of SCM research, many critical topics remain understudied,” and indicate that research is war-

ranted to enhance the theoretical foundations in logistics and SCM research.

In particular, behavioral-based research offers a critical area for further study not only in terms of theoretical development but also with respect to construct definitions, scale development, and validation. This is particularly important given the rise in behavioral-based research in the field. Recent research illustrated that one of the key emerging themes in logistics research has been a greater focus on interorganizational relationships (Georgi et al. 2010). Research examining the intellectual structure of SCM found interorganizational research to be one of three main streams of research (Charvet et al. 2008).

Our study focuses specifically on evaluating the use of trust as a key construct in interorganizational research within logistics/SCM literature. Results of a literature review indicate that although trust has been examined in a large number of studies, the construct does not have an accepted definition, and inconsistencies in scale development exist. Trust is a broad term that encompasses a great deal of complexity and, potentially, misunderstanding. As such, the standard trust scales used in logistics/SCM research may not be broad enough to truly capture the essence of such a complex construct. For example, trust may be conceptualized based on what trust entails (e.g., what the trustor examines with respect to the trustee), where trust resides (e.g., at the individual or interorganizational level), and, even, how trust develops (e.g., longitudinal aspects of trust, including the loss and potential recovery of trust).

Furthermore, as a field, we have predominantly relied on other disciplines for scale development and validation with respect to trust (e.g., psychology, organizational behavior, marketing) while often ignoring the potential for content validity issues that may result from contextual modifications. Content validity “refers to the adequacy with which a measure assesses the domain of interest” (Hinkin 1995, 968). As such, trust scales that were developed to understand interpersonal trust in the context of a spousal relationship may not be valid when applied to interpersonal trust between a buyer and a sales representative. Confidence in content validity of a measure does not automatically transfer as a singular property of that measure—rather, content validity should

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be confirmed whenever existing measures are used in substantially different research settings.

Finally, McEvily and Tortoriello (2011) analyze 171 papers published in the past 48 years in the organizational literature, and find 129 different measures of trust—few of which were strongly replicated and/or supported through construct validity. As advocated by Goldsby and Autry (2011), SCM researchers need to focus on greater validation of concepts. Trust represents a key area in need of such validation. In fact, a new journal was recently created, the *Journal of Trust Research*, with a mission to “open the *black box* of trust” (Li 2011, 2). Logistics and SCM researchers need to be involved in this ongoing debate and study of trust given that “it has been generally accepted that trust is imperative to constructive interpersonal, interfirm and international interaction and cooperation” (Li 2011, 1). We should not continue to rely on trust definitions and scales from the past and other disciplines without understanding current developments and enhancements. That is not to say that these definitions and scales are wrong, *per se*; however, as a discipline, we need to ensure that the scales we use are valid and reliable in our context given the current knowledge base.

The purpose of this study was to review the various definitions and applications of trust from a multidisciplinary perspective, and to examine, specifically within the logistics/SCM literature, how trust has been operationalized from a measurement perspective. We focused on two specific research questions: (1) what is the state of scale development with respect to trust to understand how trust has been measured and used in our discipline? and (2) is there consensus with respect to how trust has been measured and conceptualized to understand issues of scale validity? As a result of this review and empirical analysis of trust measures, we propose a framework for examining trust as well as a future research agenda that can lead to a more thorough, valid, and enhanced understanding of trust within the logistics/SCM field.

LITERATURE REVIEW

Trust has been examined from various disciplinary perspectives, and numerous authors have suggested multidisciplinary frameworks to tie the varied perspectives together and/or to organize and review historic perspectives. Our focus here is not to reinvent the wheel, but rather to highlight the various philosophical traditions associated with trust as well as the current debates within and across disciplines concerning trust. As discussed by Rousseau et al. (1998, 393), disciplines have considered trust from different perspectives:

- Economic perspective: “calculative (Williamson 1993) or institutional (North 1990)”;
- Psychological perspective: “attributes of trustors and trustees and focus upon a host of internal cognitions that personal attributes yield (Rotter 1967; Tyler 1990; see Deutsch 1962...)”; and
- Sociological perspective: “trust in socially embedded properties of relationships among people (Granovetter 1985) or institutions (Zucker 1986).”

McEvily (2011) argues that trust has evolved from two dominant paradigms: economics, which emphasizes behavioral measures; and social sciences, which emphasizes attitudinal measures. Behavioral measures are “rooted in economic game theory” and enable risk-based approaches for studying trust, while attitudinal measures consider trust as a psychological state (McEvily 2011, 1268). Following this approach, Kramer (1999) differentiates trust, examined in organizational theory, as being either a “choice behavior” (p. 572) or “a psychological state” (p. 571). As Kramer (1999) concludes, there are two perspectives on choice behavior: rational choice (e.g., Williamson’s 1993 calculative perspective) and relational models of trust (e.g., Granovetter’s 1985 social embeddedness approach). With respect to psychological states, various considerations have been examined, including vulnerability, expectancy, and affective conditions (Kramer 1999). Li (2007) indicates that, while a majority of trust researchers adopt a “trust as attitude” approach, there is growing interest in the “trust as choice” approach.

Hosmer (1995, 391) develops the following four categories of trust based on various research perspectives used, comparing definitions, illustrating key assumptions, and considering contextual differences: (1) individual expectations (“nonrational behavior based upon past experiences and future forecasts”); (2) interpersonal relationships (“nonrational behavior, based upon characteristics and traits of both individuals”); (3) economic exchanges (“economically rational behavior, constrained by contracts and controls”); and (4) social structures (“socially rational behavior, directed by formal requirements and informal obligations”). Hosmer (1995) offers a fifth element, ethical principles, as an important trust consideration.

Hosmer’s (1995) categorization alludes to trust occurring at various levels, such as between individuals as well as between organizations. The level of analysis for studying trust has often been related to the disciplinary perspective, such that economists have tended to examine trust at the individual and/or the firm level, psychologists have focused on the individual and the group level, and sociologists have examined trust within the group and/or society (Rousseau et al. 1998). Ganesan and Hess (1997) propose that trust could exist at four levels: interpersonal (i.e., trust between individuals); organizational (i.e., an individual’s trust for an organization); intraorganizational (i.e., trust between an employee and employer); and interorganizational (i.e., trust between organizations).

Specific definitions of trust have developed, in part, from the perspectives of trust described above. However, researchers still contend that “a widely accepted definition of trust is lacking” (Li 2012, 101). Early definitions of trust considered trust as either an expectation or a behavioral intention (Moorman et al. 1992). Zucker (1986) offers a definition of trust based on expectations as indicated: “trust is defined as a set of expectations shared by all those involved in the exchange” (p. 54). Expectation approaches indicate that “despite uncertainty about how the other will act, there are positive expectations regarding the other party’s intentions, motivations, and behaviors” (Lewicki et al. 2006, 996). Trust as behavioral intention implies a confidence in the other party’s motives and, thus, involves risk-taking behavior. This behavioral intention “entails a willingness to accept vulnerability to the actions of another party” (Lewicki et al. 2006, 996).

Regardless of the underlying discipline, many authors combine elements of expectation as well as vulnerability as critical components for defining trust (e.g., Moorman et al. 1992; McEvily and Tortoriello 2011). Based on various definitions, Rousseau et al. (1998) proposed the following combinatory definition: "Trust is a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behaviors of another" (p. 395).

In terms of how trust constructs are measured, there remain considerable differences in opinion with respect to dimensional considerations, focal points, and scale development. Research has examined trust from both unidimensional and multidimensional considerations. For example, Lewicki et al. (2006) describe how trust and distrust has been researched from a unidimensional perspective (e.g., trust and distrust are opposite ends of a single dimension), a two-dimensional perspective (e.g., trust and distrust are separate constructs, but are measured using the same components), and a transformational perspective (e.g., different types of trust examined with the understanding that trust changes over time). Li (2007) supports this contention that "despite disagreement over the specifics of trust, scholars share the view that trust is highly complex with multiple dimensions" (p. 423).

Despite acknowledgment that trust is multidimensional and complex, McEvily and Tortoriello (2011) indicate that the majority of studies they analyzed empirically treated trust as a unidimensional construct with only a small minority of studies examining trust from a multidimensional perspective. Further complicating the issue, Lewicki et al. (2006, 997) note that unidimensional constructs may, in fact, be "multifactorial" such that the construct includes subfactors, but is treated as a "single, superordinate factor" (e.g., trust may be a single factor with both expectation and vulnerability measures). Examples of perspectives (with both elements of expectation and vulnerability) used in the broad literature include:

- Ganesan (1994) measures two distinct components of interorganizational trust: (1) credibility (one party's *expectations* about the required expertise of the other party), and (2) benevolence (one party's *beliefs* that intentions and motivations of the other party will be beneficial in the face of new conditions/changes, indicating *vulnerability*).
- Morgan and Hunt (1994) examine trust from an *expectation* perspective, considering willingness [to be *vulnerable*] to be redundant.
- McAllister (1995) measures interpersonal trust from two perspectives: (1) cognitive; and (2) affective. Cognitive trust involves *expectations* surrounding reliability and dependability, whereas affective trust entails "confident attributions concerning the motivations for that person's citizenship behavior" (McAllister 1995, 30). As such, affective trust may be considered as a willingness to trust.
- Ganesan and Hess (1997) examine credibility and benevolence at two different levels (interpersonal trust between a buyer and a sales representative and organizational trust that the buyer and seller have for each other's organization) creating a four-factor model: interpersonal credibility; interpersonal benevolence; organizational credibility; and organizational benevolence.
- Whipple and Frankel (2000, 23) measure two elements of interorganizational trust, based on Gabarro's (1987) intraorganizational work: (1) character-based trust (i.e., integrity, identification of motives, consistency of behavior, openness, discreteness); and (2) competence-based trust (i.e., specific competence, interpersonal competence, competence in business sense, and judgment) trust. Again, trusting in one's character represents elements of *vulnerability*, whereas trusting in one's competence represents elements of *expectations*.

For this study, we propose trust as a multidimensional model, combining elements of the perspectives illustrated above. The purpose of this combinatory framework is to facilitate an analysis of trust constructs used in the logistics/SCM literature. We do not suppose ours is the only trust framework, but, rather, are creating a framework for literature review and article comparison.

We propose considering trust from a character-based and competence-based perspective (Gabarro 1987; Whipple and Frankel 2000). This perspective is consistent with previous research in that it offers both elements of expectation (Ganesan 1994; Morgan and Hunt 1994) and willingness to be vulnerable (Lewicki et al. 2006) and is highly similar to credibility and benevolence as well as cognitive- and affect-based approaches. Consistent with Hosmer's (1995) multileveled categorization of trust, we also propose that character and competency should be evaluated at various levels of relationships (e.g., interpersonal, organizational).

We will examine interpersonal, organizational, and interorganizational levels of trust given the importance of interorganizational and alliance research to our field's intellectual foundation as discussed by Charvet et al. (2008) and Georgi et al. (2010). It is important to note that, while interorganizational research has largely examined how firms collaborate to enhance supply chain integration and performance, interorganizational trust examines trust that one firm has for another firm as used by Ganesan and Hess (1997).¹ Interorganizational trust can even be extended to include a network perspective (e.g., trust that exists between multiple firms). Organizational trust, as described by Ganesan and Hess (1997), is the trust that one individual has (i.e., a buyer) for another party's organization (e.g., the selling firm). We will also examine items that may be focused on the interpersonal level (e.g., one individual to another individual). Given previous research efforts in our field, these four levels of trust are most pervasive in terms of use within the context of interorganizational research. Certainly, there are also studies on intraorganizational trust (e.g., the level of trust a driver has for his/her employer). However, those studies are outside the scope of this study. Table 1 illustrates the framework we examined in this study.

RESEARCH METHODOLOGY

To begin our analysis, we conducted a search of articles published over the past 20 years in key logistics/supply chain

¹Ganesan and Hess (1997) cite Larson (1992) in their definition of interorganizational trust.

Table 1: Trust framework

Type/level	Character-based trust	Competence-based trust	General trust
Interpersonal (one individual to another individual)	A	B	C
Organizational (one individual to an organization)	D	E	F
Interorganizational (one organization to one other organization)	G	H	I
Interorganizational network (one organization to many organizations)	J	K	L

management journals to find all articles focused on researching trust. From these, we selected only articles that examined trust using empirical, quantitative analysis of primary data. Conceptual articles were not included in the analysis, nor were articles where trust was not a core focus of the research (e.g., decision-making experiments, which may have considered trust as an experimental condition).

We focused on seven journals considered to be significant logistics/SCM journals, and found 42 articles that fit the criteria. The seven journals included were as follows:

1. *International Journal of Logistics Management*
2. *International Journal of Physical Distribution and Logistics Management*
3. *Journal of Business Logistics*
4. *Journal of Operations Management*
5. *Journal of Supply Chain Management*
6. *Transportation Journal*
7. *Transportation Research Part E: Logistics and Transportation Review*

For each article identified, we reviewed and recorded key information to assess our first research question (i.e., how has trust been measured and used in the logistics/SCM discipline). For example, we recorded the following information on each article: (1) the year and journal of publication; (2) specific information about the construct used; (3) the items included in the construct; (4) whether the construct (or items) used was from a previously published instrument or was newly created; and (5) construct dimensionality. When the constructs or items were from a previously published instrument, we examined the source instrument (in many cases, we needed to trace the cited source further until we found the original source) to assess whether or not the full instrument was used and/or if items were adapted/modified from the original source material. When newly created constructs/items were included, we assessed whether or not, at least, basic validity assessments were used (e.g., reporting of Cronbach alpha for internal consistency of the scale items).

To address our second research question (i.e., is there consensus on how trust is measured), we compiled a list of each item used in the 42 identified articles. A total of 231 measurement items were catalogued. Duplicative items (e.g., asking the same information and within the same context) were deleted. In cases where the item was the same, but the context was significantly changed (e.g., an assessment of trust at an individual level vs. an assessment of trust at the organizational level), both items were retained. Ultimately, 119 unique items were retained for further analysis. As part of this filtering process, we also generalized the

items by creating consistent terminology and removing any specific context (e.g., references to a third party logistics (3PL) provider, trucking firm, etc.). To obtain consistency, when items referred to the respondent's firm, we used the term "my company," and when items referred to the other firm (e.g., the respondent firm's supplier), we used the term "my partner firm." In addition, we used consistent grammar whereby if the item was discussing one firm, "it" was used (i.e., rather than "they") and vice versa. As an example of removing specific context, if an item indicated, "I trust the 3PL," the item was modified to "I trust the partner firm."

As part of this assessment, we also wanted to understand issues with respect to measurement validity. We have focused predominantly on validity issues that would be addressed as part of early scale/survey development and measurement purification (e.g., content validity, face validity, substantive validity). As such, evaluating more advanced statistical validity (criterion-related validity, convergent validity, discriminative validity) associated with the trust measures, while certainly important, is not addressed in this article.

Our rationale for the focus on a restricted examination of validity is best summarized with a quote from Dunn et al. (1994): "If content validity does not exist, then there is no reason to proceed with the analysis because the desired construct is not being properly represented by the group of items" (p. 157). Churchill's (1979, 64) analogy of "GIGO—garbage in, garbage out" also applies such that developing measures should start with specifying and understanding the construct's domain, and, then, developing items (or searching for existing items) that capture the domain. In other words, without establishing good measures at the start, construct validity will be difficult to obtain and/or reliability will be challenging due to measurement error.

Content validity involves various considerations, and exists when the construct is properly "reflected by the items as a group" (Dunn et al. 1994, 157). For example, face validity is said to exist if the sample is appropriate (e.g., the correct domain of study) and the survey items appear to respondents as valid measures of the concept (Mosier 1947; Churchill 1979; Hair et al. 1998, 117). Although face validity is often considered one of the weakest measures of validity, face validity can be enhanced by using experts to review and judge items as well as by conducting multiple pretests across different populations (Hair et al. 1998, 117).

Anderson and Gerbing (1991) discuss the concept of substantive validity and illustrated how pretesting techniques (e.g., item-sort task) could be used to refine and eliminate items prior to survey finalization, which, in turn, should lead to stronger construct validity during empirical testing. While content validity

focuses more on how well the overall scale or items relate to the construct, substantive validity examines each individual item for its relevancy to the construct (Anderson and Gerbing 1991; Dunn et al. 1994).

Item-sort task procedures, as discussed by Anderson and Gerbing (1991), relate closely with Q-sort procedures, and also incorporate the idea of using a small, expert sample to review and judge items as proposed by Hair et al. (1998) as well as other classification schemes (as summarized in Hinkin 1995). Q-sorting was invented by British physicist/psychologist William Stephenson in 1935 as a means of extracting subjective opinion and evolved from factor analytic theory (Brown 1997).

The Q-sort procedure is used to separate items in a multidimensional construct according to their specific domain (Zait and Berteau 2011). It can be utilized on an exploratory basis or a confirmatory basis. Exploratory Q-sorting means that respondents are given the items and asked to group and identify category labels for each group of items, whereas confirmatory Q-sorting is used when categories are already labeled and respondents are asked to classify each item in one category (Zait and Berteau 2011). Confirmatory Q-sorting was used in the current research project and the input provided by our Q-sort panel helped to identify items that do not discriminate well between our constructs of interest.

A Q-sort was performed on the 119 unique items. First, we wanted to determine item consistency with respect to the level of analysis for each item (e.g., individual vs. organizational trust). As such, Q-sort participants were asked to examine each of the 119 items and determine whether the item was focused on trust at one of the following levels: (1) individual to individual (e.g., I trust him/her or he/she trusts me); (2) individual to organizational level (e.g., I trust this firm or he/she trusts my company); (3) one organization to one other organization (e.g., my company trusts this firm or this firm trusts my company); (4) one organization to many organizations (e.g., my company trusts multiple firms); or (5) none of the previous choices (e.g., I am not sure which level is appropriate). Consistency in participant agreement on the level of analysis was then assessed.

Second, we examined item consistency with respect to how trust was being conceptualized. As such, Q-sort participants were asked to examine each item and determine whether the item was focused on gauging: (1) character-based trust (i.e., defined as examining the qualitative characteristics of behavior in strategic philosophies and cultures such as integrity, true motives, consistency and predictability of behavior, openness, and discreteness); (2) competence-based trust (i.e., defined as examining the specific operating behaviors and day-to-day performance such as specific competence, knowledge, skills, ability to perform well, area of expertise, and good judgment); (3) a general level of trust (e.g., trust is not clearly specified as a specific type); or (4) none of the previous options (e.g., I am not sure which type of trust is being referred to in this question).² Consistency in participant agreement on the conceptualization was then assessed.

A total of 31 people participated in the Q-sort process. Participants were selected from three different populations to gain

disciplinary and industry perspectives: 17 participants were academicians familiar with the logistics/SCM literature; six participants were academicians familiar with the marketing/management literature; and eight participants provided an industry/practitioner perspective.

We assessed consistency from two different perspectives. First, for each item, we calculated the *proportion of substantive agreement*, a raw percentage of respondents that assign an item to the intended category or construct (Anderson and Gerbing 1991). As we were examining existing items rather than developing the items and using the Q-sort as a pretest procedure, we did not identify intended categories *a priori*. Instead, we report the category that the largest percentage of respondents deemed each item belonged to, understanding that our categorization (Table 1) may not be totally representative of the original domain of study for the 42 articles. For example, if 28 of the 31 participants indicated that an item was examining individual-to-individual trust, the proportion of substantive agreement was 90% for that item (28/31). Table 2 shows the summary breakdown for both the level and type of trust with respect to substantive agreement for the 119 unique items.

Although the portion of substantive agreement suggests an element of construct validity by illustrating the extent to which an item is categorized to represent its intended construct, it does not illustrate the extent to which an item may also be related to a different construct (Anderson and Gerbing 1991). As such, we also calculated the *substantive-validity coefficient* for each item, which examines the extent to which respondents assign an item to the intended construct more frequently than to a different construct (Anderson and Gerbing 1991). The substantive-validity coefficient is calculated by taking the number of respondents that correctly classify the item to the *a priori* construct and subtracting the highest number of respondents who assigned the same item to a different construct, and, then, dividing that number by the total number of respondents (Anderson and Gerbing 1991, 734). Again, we do not have *a priori* assignments. As such, for each item, we examined the first and second category that the largest percentage of respondents classified for each item. For example, if 22 of the 31 participants indicated that an item was examining individual-to-individual trust, and six participants indicated that the item was examining individual-to-organizational trust, and three participants were not sure, the substantive-validity coefficient was .52 for that item $([22 - 6]/31)$. Table 3 shows the summary breakdown for both the level and type of trust with respect to the substantive-validity coefficient for the 119 unique items.

Table 2: Q-Sort: Proportion of substantive agreement

Percent agreement among respondents	Level of trust	Type of trust
100%	2	2
90–99%	36	22
80–89%	18	24
70–79%	17	14
60–69%	12	22
Under 60%	34	35
Total items	119	119

²The definitions of character- and competence-based trust are based on Gabarro (1987) and Whipple and Frankel (2000).

Table 3: Q-sort: Substantive-validity coefficient

Coefficient range	Level of trust	Type of trust
1.0	2	2
.90-.99	23	11
.80-.89	15	20
.70-.79	11	12
.60-.69	7	9
.50-.59	15	8
Under .50	46	57
Total items	119	119

On the basis of the results of the Q-sort and the analysis shown in Tables 2 and 3, we evaluated the 119 items to indicate where content validity and substantive validity is likely to be higher. Similar to Cronbach alpha and factor analysis cut-off recommendations, there is no established rule with respect to what degree of substantive agreement or substantive-validity coefficient is required to retain an item after pretesting. Anderson and Gerbing (1991) indicate for both measures, larger values indicate greater validity. General guidelines for Q-sort procedures consider scores of 65% or greater to be acceptable (Jarvenpaa 1989). As such, we took a conservative approach and used 70% as a cutoff based on the agreement results shown in Table 2. Each item was also examined with respect to the substantive-validity coefficient. All of the items meeting or exceeding the 70% cutoff for agreement had substantive-validity coefficients at .50 or above with the except of two items in the level of trust Q-sort and two different items in the type of trust Q-sort.

RESEARCH SUMMARY RESULTS

From the analysis, we were able to analyze the literature published to understand the overall landscape with respect to how trust has been conceptualized in the logistics/SCM literature. Since 1993, a total of 42 articles were published on trust in the seven journals of interest. The first empirical article to include

trust did not appear until 1995. The vast majority (83%) of the articles that examine trust have been published in the last 10 years. The results illustrate an increasing interest in examining trust in the logistics/SCM literature. Figure 1 illustrates the frequency of trust articles published over the 20 years of research included in this article.

As shown in Figure 2, the majority of the articles (71%) were published in three journals: *Journal of Business Logistics*, *Journal of Operations Management*, and *Journal of Supply Chain Management*. Of the full set of articles, the majority (78%) used existing scales, at least to some extent. As shown in Figure 3, 26% of the articles adopted the full set of items from the cited source, 31% used a partial set of items from the cited course, 14% used a partial set of items from two or more sources. For articles using new scales, 7% mixed newly developed scales with items from a published source while 22% of the articles created completely new items. Of the nine articles that used new items and/or new scales, only 5 (55%) provided evidence of, at least, basic construct validity testing (e.g., Cronbach alpha).

Of the 31 articles that included at least one trust-oriented item from an existing publication, we assessed the discipline from which the original source resided. Note: we found numerous incidents of articles citing a source article only to find that the source article was not the original source for the item. It was also not uncommon for the original source to be at least one source removed, as authors cited sources of measures that were, in fact, not the original sources; rather, the “source” had adopted original measures from yet a different source article. Figure 4 illustrates that the majority of the source articles were from the marketing discipline (53%), followed by the organization behavior/management literature (21%). Only two sources originated within the logistics/SCM literature, and neither source was a referred journal publication.

Table 4 provides a list of the first-level source articles. The table illustrates the number of times the source scales were replicated (i.e., the number of times this particular source article was used in the 42 logistics/SCM articles examined within this article). Replication does not necessarily mean the full construct and/or all construct items were used in the subsequent study; rather, it refers to the use of these measures in some form in

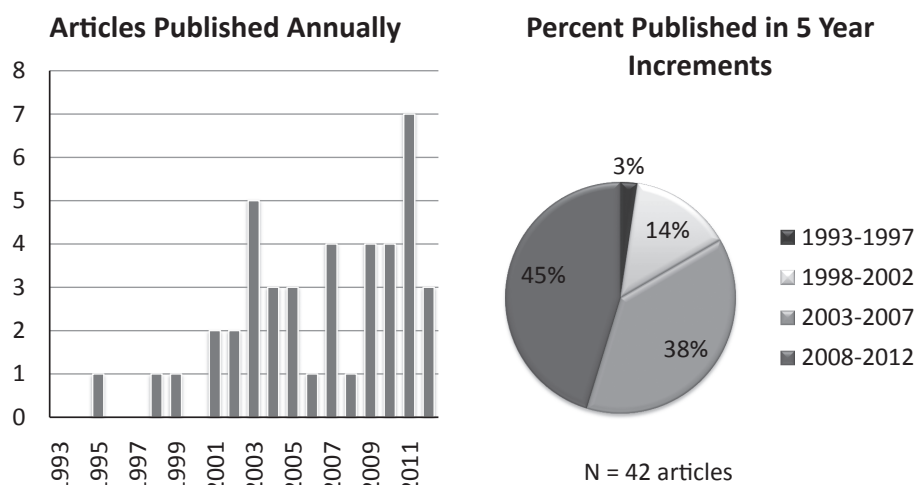
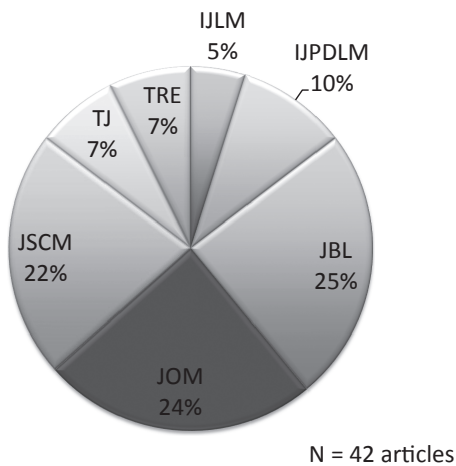
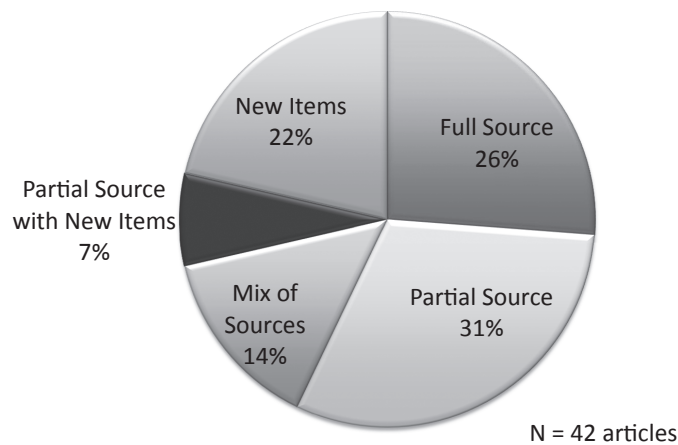
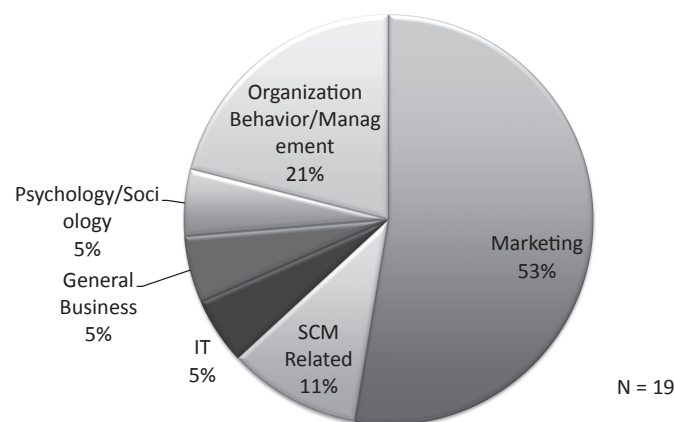
Figure 1: Publication frequency.

Figure 2: Percentage of publications by journal.**Figure 3:** Construct development summary.**Figure 4:** Reference sources by discipline.

subsequent research. The table also lists the citation journal to illustrate the source discipline. The Appendix contains the citations for the 42 logistics/SCM articles.

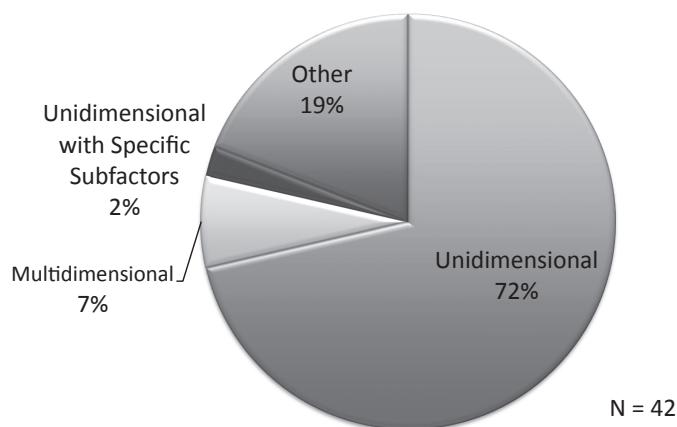
Additional analysis focused on the dimensionality of trust in the articles under study. As discussed previously, there is general

Table 4: Source citations and frequency of replication

Measurement instrument source	Number of replications
Doney and Cannon (1997), <i>Journal of Marketing</i>	10
Kumar et al. (1995), <i>Journal of Marketing Research</i> ; and Larzelere and Huston (1980), <i>Journal of Marriage and Family</i>	6
Morgan and Hunt (1994), <i>Journal of Marketing</i>	4
Ganesan (1994), <i>Journal of Marketing</i>	3
Cummings and Bromiley (1996), <i>Trust in Organizations</i>	2
Sin et al. (2005), <i>Journal of Business Research</i>	2
Cahill (2006), <i>Customer loyalty in third party logistics relationships: findings from studies in Germany and the USA</i>	1
Deepen (2007), <i>Logistics Outsourcing Relationships: Measurement, Antecedents, and Effects of Logistics Outsourcing Performance</i>	1
Jap (1999), <i>Journal of Marketing Research</i>	1
Joshi and Stump (1999), <i>Journal of the Academy of Marketing Science</i>	1
McKnight et al. (2002), <i>Information Systems Research</i>	1
Moorman et al. (1993), <i>Journal of Marketing</i>	1
Moorman et al. (1992), <i>Journal of Marketing Research</i>	1
Plank et al. (1999), <i>The Journal of Personal Selling and Sales Management</i>	1
Perrone et al. (2003), <i>Organization Science</i>	1
Robson et al. (2008), <i>Organization Science</i>	1
Sin et al. (2002), <i>Journal of Services Marketing</i>	1
Zaheer et al. (1998), <i>Organization Science</i>	1

consensus that trust is a multidimensional and complex construct. As such, we would assume that authors would consider it appropriate to model trust as a multidimensional construct where distinct dimensions of trust were measured (with multiple items) and trust was essentially conceived as a higher order construct (e.g., trust considered as resulting from two distinct dimensions, such as honesty and benevolence). However, we found that not to be the case. Rather, as shown in Figure 5, only three (7%) of the articles reviewed considered trust to be a multidimensional construct.

In the vast majority of instances, trust was tested as a unidimensional construct. In 30 articles, trust was assessed using a single construct with numerous items. Sometimes, the items were “generic” items of trust (e.g., the firm is trustworthy or I trust him), and other times, a mix of “dimensions” of trust items were included (e.g., benevolence, credibility, etc.). In a few cases, the authors used two single, but independent, constructs of trust (e.g., salesperson trust and organization trust), but did not attempt to test the two constructs as related to a higher order trust construct. However, none of the 30 articles discussed trust

Figure 5: Construct dimensionality.

being conceptualized as a construct with subfactorial design. There was one article that considered trust as a unidimensional construct made up of specific subfactors (i.e., benevolence and credibility).

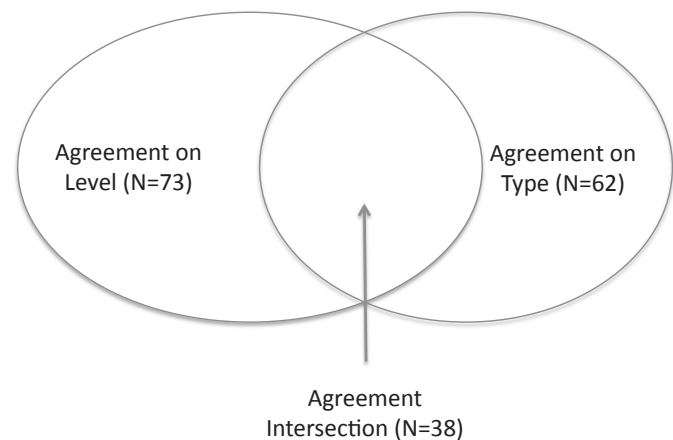
The remaining eight articles were coded as “other” with respect to construct dimensionality. In five of these articles, trust was measured as a subfactor for a higher order factor. However, the higher order factor was not trust—rather, higher order factors were constructs, such as relationship magnitude, supply chain orientation, relationship orientation, and customer partnering behavior. In the remaining three “other” articles, trust was a single-item measure used in a plethora of other measures without construct development.

Table 5 summarizes how each article conceptualized trust as a construct. As shown in the table, the vast majority of the articles indicated the construct being measured was “trust.” In some articles, two different trust-related constructs were measured, such as benevolence and partner’s honesty or calculative trust and affective trust.

After examining the data to assess the general status of trust as it has been used in the logistics/SCM literature, the next step was to analyze the Q-sort data to gain an understanding of elements of content and substantive validity. As indicated in Table 2, 73 items met or exceeded the 70% cutoff point for agreement for the level of trust, representing 61% of the total 119 items. Of these 73 items, 52 (71.2%) were categorized as focused on trust between one organization and one other organization. The remaining items were categorized as follows: 11 items (15.1%) were trust between an individual and an organization; six items

Table 5: Construct name and frequency

Construct name	Frequency of usage
Trust	38
Benevolence	4
Partner’s honesty	2
Dependability	1
Objective credibility	1
Calculative trust	1
Affective trust	1

Figure 6: Q-sort agreement and agreement intersection.

(8.2%) were trust between one organization and many organizations; and four items (5.5%) were trust between individuals.

Table 2 also shows that 62 items met or exceeded the 70% cutoff point for agreement for the type of trust, representing 52% of the total 119 items. Of these 62 items, 54 of the items (85.5%) were categorized as character-based trust. The remaining nine items (14.5%) were categorized as competence-based trust.

Figure 6 depicts the overlap between items that achieved consensus upon *level of trust* and *type of trust*. A total of 38 items had the minimum (70%) substantive agreement on both construct aspects. As shown in Table 6, the vast majority of these 38 items were categorized by participants as being character-based trust at the interorganizational level (one organization to one other organization). Table 7 provides the actual questionnaire items as well as where each of these 38 items falls within our proposed framework (Table 1).

In addition, we catalogued the items that have the least clarity with respect to agreement on the level and/or type of trust. Items, where seven or more Q-sort participants (roughly 25% of the Q-sort sample) indicated that they did not know what level or type of trust the item was intended to measure, were deemed to lack clarity within our framework.³ Furthermore, any items, which had a substantive-validity coefficient of zero, were also considered to be poorly specified, as Q-sort participants were split 50/50 in their assessment of the item as being in one of two categories (e.g., half of the participants felt the item related to general trust and half of the participants were unsure which category the item belonged to). Table 8 lists the specific items with the least agreement.

DISCUSSION

Logistics and SCM research has become progressively more sophisticated since the *Journal of Business Logistics* published

³It is important to note that we are not determining the validity of these items with respect to how they were used in the original logistics/SCM article. Rather, we are using our framework to determine its ability to categorize and understand these measurement items.

Table 6: Agreement interaction within the framework

Type/level	Character-based trust	Competence-based trust	General trust	Total
Interpersonal (one individual to another individual)	2	0	0	2
Organizational (one individual to an organization)	8	0	0	8
Interorganizational (one organization to one other organization)	23	3	0	26
Interorganizational network (one organization to many organizations)	2	0	0	2
Total	35	3	0	38

Table 7: Items with agreement interaction

Questionnaire item	Code from Table 1
This person is trustworthy	A
This person does not make false promises	A
I feel that this partner firm negotiates honestly	D
I feel that this partner firm does not try to get out of commitments	D
I feel that this partner firm negotiates joint expectations fairly	D
I think that the partner firm tells the truth in business dealings	D
I feel that the partner firm dealt with me honestly	D
I feel that the partner firm succeeds by stepping on other people	D
I think that the partner firm took advantage of my problems	D
I feel that the partner firm takes advantage of people who are vulnerable	D
We can count on the partner firm to consider how its decisions and actions will affect us	G
When we share our problems with the partner firm, we are confident that it will be understanding	G
In our relationship, the partner firm is sincere in its promises	G
In our relationship, the partner firm treats my company fairly and justly	G
If the partner firm gives us some advice, we are certain it is its honest opinion	G
Regarding problems, this partner firm is always honest with us	G
We trust this partner firm keeps our best interests in mind	G
This partner firm embodies the values we hold to be most important	G
This partner firm deals with us in a straightforward manner that reveals its true motives and desired outcomes	G
My company is accustomed to keeping the best interests of the partner firm in mind	G

Table 7: (Continued)

Questionnaire item	Code from Table 1
The partner firm is fair in its dealing with your company	G
We know this partner firm is sincere with us	G
This partner firm never uses opportunities that arise to profit at our expense	G
This partner firm is interested in our company's well-being and not just its own	G
This partner firm is truthful in its dealings with our company	G
Our company would characterize this partner firm as being honest	G
Our company feels that this partner firm cares about what happens to us	G
This partner firm is always frank and truthful in its dealing with us	G
We believe in this partner firm because it is sincere	G
This partner firm has always been evenhanded in its negotiation with us	G
Even when the partner firm gives us a rather unlikely explanation, we are confident that it is telling the truth	G
The partner firm usually keeps the promises that it makes to our company	G
When making important decisions, it is customarily expected that my company consider the partner firm's welfare alongside its own	G
The partner firm correctly carries out tasks that we cannot directly control	H
This partner firm is competent and effective in its interactions with our company	H
It is necessary for us to be confident about the competence of this partner firm	H
Our company and these firms are very honest in dealing with each other	J
Please describe the degree of trust that exists between your company and the partner firms:	J
The extent to which these firms are well known for their fair dealing	

Continued.

Table 8: Items generating the least agreement*

Level of trust	Type of trust
<i>Please describe the nature of this partner firm's relationship governance structure</i> (17)	<i>Please describe the nature of this partner firm's relationship governance structure</i> (21)
The level of trust in this relationship is very high. (16)	My company expects that all kinds of procedures in the relationship with the partner firm will become self-evident (10 and SVC)
<i>Whoever is at fault, problems need to be solved together</i> (15)	<i>Whoever is at fault, problems need to be solved together</i> (10)
The salesperson will always use good judgment (12)	It would be illogical for the partner firm to abuse my company's trust (10)
In general, this partner firm is knowledgeable about its industry and business operations (11)	My company will be able to understand the partner firm well (10)
<i>Please describe the level of trust toward this partner firm</i> (11)	Both parties watch the other's profitability (9)
<i>This salesperson's firm has a poor reputation</i> (11)	The salesperson did everything possible for our company (8)
This salesperson is not a real expert (11)	My company is able to understand the partner firm's positive behaviors (8)
This salesperson's firm has quality people working for it (11)	<i>Both parties are willing to make mutual adaptations</i> (7)
The partner firm brings high ethical standards to its work (10)	<i>Please describe the level of trust toward this partner firm</i> (7)
This partner firm performs all of its roles very well (10)	<i>This salesperson's firm has a poor reputation</i> (7)
This partner firm is sincere and genuine (10)	
The purchasing agent has high integrity (9)	
The purchasing agent is overall trustworthy (9)	
Overall, this partner firm is capable and proficient (9)	
The partner firm is trustworthy (9)	
It is critical for this partner firm to fulfill its obligations even without being monitored (9)	
The partner firm adheres to an acceptable set of principles (9)	
There are no doubts regarding the partner firm's motives (9)	
This is a highly knowledgeable manager (8)	
This partner firm keeps its commitments (8)	
This partner firm cannot be trusted at times (8)	
This partner firm is always faithful (8)	
This partner firm has a high level of integrity (7)	
This partner firm does not make false claims or promises (7)	
<i>Both parties are willing to make mutual adaptations</i> (7)	
The partner firm lives up to the spirit of its commitments (7)	
Promises made by these partner firms are reliable (7)	

Notes: *After each item, there is a number in parentheses. This indicates how many of the 31 Q-sort participants did not know how to categorize this item. Also, for any items where the substantive-validity coefficient was zero, this is indicated as SVC in the parentheses. Italics indicate that the item is on both the level of trust and the type of trust lists.

its first issue some 35 years ago. Although there have been many important contributions to theory and practice, many opportunities still exist for improvements to the field. We focus on one such opportunity—better scale development. While we selected trust for examination, it is likely that virtually all of our field's constructs/research efforts could benefit from improved measures. Developing better scales has the potential for significantly improving our chance of conducting meaningful research and theory advancement. Researchers constantly fight the battle to secure adequate responses and “good data.” With better, more precise scales that are user friendly, perhaps, we will enjoy better response rates and lessen participant fatigue.

The lack of replication of trust measures to date suggests that researchers in the field are unsatisfied with the existing measures. Or, as suggested by McEvily and Tortoriello (2011) when dis-

cussing the nascent state of trust in the organizational literature, “It may also be the case that ‘necessity is the mother of invention’ and that organizational researchers have devised idiosyncratic measures of trust due to the lack of availability of carefully designed and validated instruments” (p. 35). Regardless of the reason, our analysis underscores the need for greater scale development. For example, numerous gaps can be observed in Table 6 revealing areas where no measures achieved sufficient agreement among our panel of respondents. Researchers are urged to focus on new scale development and purification of scales in cases where insufficient clarity currently exists, as the available supply of measures appears low. The starting point should be better conceptual definitions, sound theoretical bases, face validity, and use of pretest logic such as detailed here (Q-sort) to purify the scale prior to distributing surveys. Until these

basic qualities can be attained, concern about discriminant and convergent validity as well as reliability associated with the constructs developed from trust measurement items is likely to continue as advanced validity is potentially being assessed based on a weak foundation.

It is also important that logistics and supply chain researchers make greater effort to precisely document scale items in their published manuscript. For example, while there is a temptation to shorten manuscripts to conserve space, full scale items including any lead-in (explanation of responding to the items/questions) should be included. When existing scale items are used or modified, full credit should be given to the researcher(s) who originally developed the scale.

To be clear, we are not advocating for or against any of the measures described above; merely, we suggest that work remains in developing a set of clearly understood, useful measures of trust to guide the interorganizational relationship research within our discipline. Given that we only had access to the survey information provided by the authors in the 42 articles we examined and not the original survey instruments, it may be that the assessed measures were more readily specified and understood by the respondents of those surveys. However, this further adds to our call that more complete information be reported about measurement scales, to facilitate the type of replication necessary for advancement of logistics and supply chain research (Goldsby and Autry 2011).

CONCLUSIONS AND FUTURE RESEARCH

As results illustrate, significant opportunities exist for contribution to the field through the development of valid measures of trust in the logistics and supply chain setting. It appears as though sufficient measures of interorganizational (e.g., one organization to another organization), character-based trust exist. However, scale development and testing is warranted in other areas suggested by our framework. For example, interorganizational, competence-based trust, while possessing a minimum number of measures ($n = 3$), likely would benefit from additional scale development as would organizational, character-based trust ($n = 8$). All other areas within the framework reveal a lack of well-understood measures. The fact that only two measures of interpersonal trust, not enough to build a credible construct, were consistently understood by respondents indicates that sufficient work remains in this important area of trust assessment. Last, although interorganizational network trust appears to be a special case, it is clear that additional scale development is needed at this level of trust. This development is particularly important given the increase in interest in logistics/SCM research focused on social network theory and social network analysis methods.

In summary, trust is obviously a prime area for future research. Intense work is needed on scale development that offers a multidimensional framework, which would more accurately reflect the true complexity associated with trust. Once scales are developed and initially tested for "early validity" (content and substantive), testing and empirically validating (convergent, discriminant, criterion-related validity) such items using multiple subsamples is warranted.

APPENDIX: STUDIES INCLUDED IN THIS REVIEW

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Environmental Development of Emerging Economy Suppliers: Antecedents and Outcomes

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As supply chains spread toward emerging economies, Western buying firms frequently face the question of whether they should commit resources to develop their suppliers in these regions in terms of environmental issues. Supplier development researchers have just begun to consider environmental aspects, and thus far, the peer-reviewed literature has remained primarily qualitative, and often descriptive. Large-scale empirical evidence indicating the antecedents and benefits of environmental supplier development for a buying firm is still scarce. Addressing this gap, we use stakeholder theory to complement and extend the work of Ehr Gott et al. (2011) and investigate how pressures from customers, governments, and employees act as antecedents to environmental supplier development. Furthermore, we build on the resource-based view to examine how supplier capabilities, buying firm environmental reputation, and organizational learning in the buying firm can result from such supplier development initiatives. We test the resulting model with a sample of 244 corporate procurement executives from the United States and Germany.

Keywords: environmental sustainability; supplier development; emerging markets; international purchasing; stakeholder theory; resource-based view

INTRODUCTION

As supply chains spread toward emerging economies (Kusaba et al. 2011; Gereffi and Lee 2012), the debate about the responsibility of Western buying firms to educate their suppliers with regard to environmental issues has become increasingly relevant to supply chain and sustainability research. Suppliers from many parts of Asia, Eastern Europe, and Latin America often lack the necessary managerial and technological capacities, as well as the awareness to address the environmental issues inherent in their businesses (Child and Tsai 2005; Zhu et al. 2011). Thus, buying firms in developed nations that source from these regions face the question of whether to commit resources to environmental concerns beyond their own organizational boundaries, toward their upstream supply chains (Pagell and Wu 2009; Bai and Sarkis 2010). The supplier development literature has only recently started to recognize such environmental efforts as part of firms' supplier development initiatives. This recent literature has focused on providing a descriptive overview, formal modeling, or case-based investigation of issues related to environmental supplier development (Pagell and Wu 2009; Bai and Sarkis 2010; Reuter et al. 2010; Fu et al. 2012). While Ehr Gott et al. (2011) examine the influence of key stakeholders to *socially* sustainable supplier *selection*, we note a dearth of large-scale empirical studies that examine the stakeholder antecedents to buying firms' engagement in *environmental* supplier *development* efforts, and the precise benefits the buying firm can reap through such engagement. Notable exceptions that have made initial headway into the phenomenon are Eltayeb et al. (2010) and Vachon and Klassen (2008). We add to this evolving stream by

investigating two research questions: (1) Which stakeholder pressures act as antecedents for Western buying firms to engage in developing the environmental capabilities of their emerging economy suppliers? and (2) Which tangible benefits can firms capture through such environmental supplier development efforts?

Our definition of "environmental supplier development" encompasses all activities through which the buying firm helps its suppliers reduce their negative environmental impact. Such activities typically include environmental supplier education (e.g., training that reduces emissions through better filtering and waste treatment, as well as improved efficiency in production technology), environmental on-site supplier support (e.g., provision of on-site technical assistance to redesign existing processes), and joint environmentally oriented business projects (e.g., collaboration to jointly develop green innovations and technologies) (Carter and Carter 1998; Min and Galle 2001; Eltayeb et al. 2010). Also, such activities typically involve several of the buying firm's functions (including purchasing, research and development [R&D], production, human resources, and logistics) to collaborate in a cross-functional team (Schaefer and Kosansky 2008; Paulraj 2011). We denote firms' environmental efforts in general (i.e., beyond environmental supplier development) using the term "environmental sustainability" and efforts including both environmental and social sustainability aspects by the broader term "sustainability."

The theoretical lenses through which we examine our research questions are stakeholder theory (Freeman 1984; Frooman 1999) and the resource-based view (RBV) of the firm (Wernerfelt 1984; Barney 1991)—concepts that scholars frequently draw on for investigating sustainability efforts (Clarkson 1995; Hart 1995; Sharma and Vredenburg 1998; Aragon-Correa and Sharma 2003; Garriga and Melé 2004; Ehr Gott et al. 2011).

Stakeholder theory posits that firms must consider a broader set of stakeholder interests—beyond financial firm performance—to maintain their business activities in the long run (Freeman 1984). These interests increasingly include the preservation of the natural

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environment (Phillips and Reichart 2000), which provides the fundamental means of existence for the firm. In our research, we look specifically at the role of employees, governments, and customers in influencing the firm's environmental supplier development decisions, particularly because the existing sustainability literature has found conflicting evidence on their influence, depending on the specific study context.

Concerning the influence of employees, Reuter et al. (2010) conduct case study-based work and find that top management employees (rather than middle management or lower level employees) are a primary antecedent to the purchasing function's involvement in, for example, emission reductions and waste treatment improvements. In contrast, Ehr Gott et al. (2011), Carter et al. (2007), and Carter and Jennings (2004) find that middle managers have a significant driving role in other sustainability activities of the purchasing function. In terms of government influence, Walton et al. (1998) find governments serving as antecedents for some firms' environmental activities in the supply chain (e.g., selection of environmentally friendly input factors and environmentally friendly product designs). However, Carter and Carter (1998) and Carter and Jennings (2004) find no influence from governments on other types of environmental activities (e.g., reusing and recycling packaging materials). Regarding customers, Pomeroy and Dolnicar (2009) and Maignan (2001) find no influence on other sustainability efforts. However, Deephouse and Heugens (2009) and Ehr Gott et al. (2011) propose such influence. To our knowledge, no large-scale empirical evidence exists on the antecedent role that these three stakeholder groups play with regard to the specific context of environmental supplier development. Thus, an investigation seems warranted. For our study, we develop a theoretical framework in which we argue that each of these three stakeholder groups positively influences the intensity with which buying firms engage in environmental supplier development efforts.

The RBV complements the stakeholder perspective in that it focuses on the unique organizational resources that allow a firm to differentiate itself from the competition (Wernerfelt 1984; Barney 1991). Numerous scholars emphasize that environmental strategies allow firms to augment their resource base, in particular by enhancing their ability to continuously innovate, meet market requirements, and integrate with other stakeholders, such as upstream business partners (Hart 1995; Sharma and Vredenburg 1998; Aragon-Correa and Sharma 2003; Hitt 2011). In our study, we tie in with the findings by Sharma and Vredenburg (1998), who propose that three primary resources firms can augment through their environmental efforts relate to their technological and managerial capabilities, their standing with stakeholders, and increased internal organizational learning. For the context of our study, these resources translate into three hypothesized outcomes of environmental supplier development: suppliers' strategic capabilities, the buying firm's environmental reputation, and organizational learning in the buying firm's purchasing function.

We test our model with a sample of 244 purchasing managers from buying firms in two home countries: the United States and Germany. Firms in both countries source significant parts of their purchasing volumes from emerging economies (Kaufmann and Carter 2002; Ruamsook et al. 2007). Our definition of emerging economies is based on the Forbes-accredited ISI Emerging Mar-

kets list, resulting in the inclusion of 50 relevant sourcing countries. (See the Methodology section and Appendix 1 for further details.)

The remainder of this article is organized as follows. Next, we provide a brief review of the literature on environmental supplier development. We then develop the hypotheses that determine our theoretical framework, using an antecedent-environmental supplier development-outcome structure and building on prior research in the field. Subsequently, we describe the study's methodology. In the final sections, we present the empirical findings, discuss implications and limitations, and identify directions for future research in the area.

ENVIRONMENTAL SUPPLIER DEVELOPMENT LITERATURE AND CONCEPT

During the past two decades, the literature on supplier development has evolved significantly (Hartley and Jones 1997; Krause and Ellram 1997; Krause et al. 1998; Sánchez-Rodríguez et al. 2005; Wagner 2006). Leenders (1966) describes "supplier development" as a buying firm's efforts to improve its suppliers' performance. More recently, scholars in the area have started to argue for a more fine-grained perspective on supplier development—one that accounts for the conceivably very different goals behind such initiatives (Krause 1999; Wagner and Krause 2009). In this respect, Krause (1999) finds improvements in quality, delivery, cost structure, new technology adoption, financial health, and product design capability as frequent underlying objectives. Krause and Handfield (1999) add to this list the improvement of communication and alignment of procedures in the buyer-supplier relationship, which aim at lowering future coordination costs.

Depending on the priority of these goals for the buying firm, the magnitude and type of interventions with the suppliers' processes and operations as part of supplier development programs differ (Wagner and Krause 2009). For example, delivery-oriented supplier development might include changes in the supplier's logistics and production planning routines. Product design-oriented supplier development, by contrast, might focus more on changes in R&D processes, the product input factor portfolio, and production/assembly equipment and processes.

The notion that the development of suppliers might also serve environmental goals has only recently entered the supply chain literature. In this vein, Bai and Sarkis (2010) note that "investigation into [environmental] supplier development programs is virtually non-existent" (p. 1200). One of the few established terms in the field was coined by Vachon and Klassen (2008). They refer to joint ecological efforts between buying firms and suppliers as "environmental collaboration," which typically includes environmental supplier training (to spur initiatives such as emissions reduction, advanced waste treatment, and resource efficiency), on-site intervention with suppliers' production processes and operations to improve their environmental footprint, and joint projects to develop green innovations (Carter and Carter 1998; Min and Galle 2001; Eltayeb et al. 2010; Azadegan 2011). Several major corporate projects targeted at environmental supplier development have recently been made public. BASF, the multinational chemicals conglomerate, has launched a joint

initiative with the United Nations Global Compact, the United Nations Industrial Development Organization, and the United Nations Environment Program to increase environmental performance of smaller and medium-sized suppliers in emerging economies. As part of the project, BASF and its partners assess supplier performance in terms of energy consumption, emissions, toxicity, and materials consumption; BASF experts also engage in technical cooperation projects by providing coaching and technical support on-site at various suppliers (Bethke and Bluethner 2003). Similar initiatives were launched at other firms, including Pentland, Nike (UNIDO 2004), and Coca-Cola (Jordan 2011). The program initiated by Pentland and Nike, for example, involves developing small and medium enterprise suppliers to meet international standards around chemicals use and disposal. Vachon and Klassen (2008) note that, contrary to control-oriented concepts (e.g., supplier monitoring), such supplier development efforts are targeted less at a supplier's immediate environmental impact and more at building the supplier's long-term capacity to operate in an environmentally sound way.

The question of what antecedes firms' engagement in environmental supplier development and what outcomes such efforts have is not well addressed in the peer-reviewed literature. In identifying potential antecedents, we thus integrate the broader sustainability literature that has continuously studied how different stakeholder pressures spur firms' commitment to sustainability activities (Henriques and Sadorsky 1999; Klassen 2001; Ehrhardt et al. 2011). This stakeholder perspective is also novel to the broader literature field on supplier development, where the discussion of antecedents has focused mainly on top management recognition of the purchasing function, importance of purchased items, interfirm communication quality, and supplier commitment, among others (Krause 1999; De Leeuw and Fransoo 2009).

Regarding outcomes, it seems particularly interesting to investigate whether efforts that are primarily targeted at improving environmental shortcomings at the supplier site also yield broader benefits for the buying firm and thus provide even greater justification for these development programs. To identify such possible broader benefits, a resource-based perspective can be employed to consider how the complex and intensive efforts behind environmental development programs allow the firm to build or augment its competitive resource base. For example, efforts to improve suppliers' resource efficiency/emissions footprint might closely relate to an upgrade of their production technology standards, and thus to the buying firm benefiting from better product quality and delivery reliability.

Studying the questions about antecedents and outcomes of environmental supplier development appears particularly fruitful in the context of relationships that Western firms have with emerging economy suppliers. Wouters et al. (2007) argue that the areas in which suppliers from emerging economies need to be developed might substantially differ from those of suppliers in mature markets. In particular, the lesser developed infrastructure and more rudimentary legal systems in such regions (Reimann et al. 2012) might lead buying firms to more intensively focus on sustainability related supplier development programs than they do in mature market environments. We subscribe to this view and expect the examined relationships to be particularly pronounced in emerging economy settings, because the gap

between actual and desired environmental performance is likely to be greater than it would be for suppliers in mature markets (Child and Tsai 2005; Zhu et al. 2005, 2011).

ANTECEDENTS OF ENVIRONMENTAL SUPPLIER DEVELOPMENT

Stakeholder theory (Freeman 1984) has been fundamental in providing a more precise understanding of both the environmental pressures a firm faces and the suitable strategies (i.e., environmental activities) firms can use to respond to them (Waddock and Graves 1997; Henriques and Sadorsky 1999). Freeman (1984) defines stakeholders as "any group or individual who can affect or is affected by the achievement of the firm's objectives" (p. 25). We focus our investigation on customers, governments, and middle managers—constituencies whose influence on firms' sustainability activities has been found to differ strongly, depending on the specific type of sustainability effort investigated. Accordingly, we develop hypotheses concerning the specific links among pressures from customers, governments, and middle managers and environmental supplier development efforts.

Customer environmental pressures

We define customer environmental pressures as the importance that customers of the buying firm attribute to environmental aspects in the upstream supply chains in their buying decisions (Drumwright 1994; Sen and Bhattacharya 2001; Christmann 2004). We have chosen to measure pressure from the buying firm's direct customers, that is, for business-to-business (B2B) firms from other companies in the downstream supply chain and for business-to-consumer firms from the end-consumers of their products. Particularly for B2B firms, our preinterviews revealed that the strongest pressure typically comes from customers who have the most direct contact.

Customers, in their scrutiny of environmental issues, increasingly consider activities in the upstream supply chain and thus beyond the firm's own production processes (Ciliberti et al. 2009; Hietbrink et al. 2010). Therefore, customers might demand products that are guaranteed to be manufactured end-to-end with low emissions and without harmful waste materials (Carter and Jennings 2004). Rising media coverage and legal requirements that compel firms to provide customers with such information foster this development (Carter and Rogers 2008; Deephouse and Heugens 2009). The concept of customer/company identification (Sen and Bhattacharya 2001) lends support to our expectation that if firms receive environmental pressures by their customers, they might see environmental supplier development as an effective means to deliver on such expectations. Particularly, customers are likely to prefer engaging in business relationships with companies that match their environmental values and to avoid doing business with firms that fail to do so. Environmental supplier development requires the allocation of significant resources (Bai and Sarkis 2010), thus signaling a firm commitment to environmental causes and congruence with the values of those customers who strive for environmental improvements themselves. Not least, environmental

supplier development can reduce the risk of spills and other environmentally harmful incidents at the supplier sites (Lee and Klassen 2008) that the buying firm's customers would consequently judge negatively. Together, these considerations suggest that environmental supplier development is a suitable response to environmental customer pressures. Hence:

H₁: *Customer environmental pressures are positively related to environmental supplier development.*

Government environmental pressures

Government pressures refer to the strength with which a firm's home country government pushes firms to undertake greater environmental efforts. We opt for this home country perspective (Ehr Gott et al. 2011) because environmental regulation in the United States and Europe has seen a strong rise in stringency (Emmelhainz and Adams 1999; Goldsby and Stank 2000; Mollenkopf et al. 2005) and ranks among the most advanced with regard to covering firms' upstream supply chains (Linton et al. 2007). Our conceptualization incorporates not just the level of current environmental regulatory pressures but also expectations about future pressures.

In terms of the firm's environmental supplier development efforts, expectations about future, heightened regulation are particularly likely to influence firm conduct. Firms that expect regulators to set higher environmental standards in the future would tend to engage in supplier development in the present to prepare for the changes, thus ensuring that their supply base meets the anticipated requirements. In doing so, the buying firm reduces the risk of high readjustment costs (e.g., supplier switching costs) if tighter environmental regulations are implemented (Barnett and King 2008; Ehr Gott et al. 2011). Environmental supplier development in itself might not be the most obvious response to environmental government pressures because it seldom addresses the entire supplier base (thus not necessarily leading to consistent standards) and it takes time to implement (thus not effectively addressing regulation that requires immediate adherence). Still, looking at prospective future tightening of regulation, environmental supplier development allows the buying firm to keep business relationships with suppliers that are not or will not be able to reach the required environmental standards by themselves, but who are generally good business partners. Hence:

H₂: *Government environmental pressures are positively related to environmental supplier development.*

Middle management environmental pressures

We conceptualize environmental pressure from employees by focusing on the influence of one specific group of employees: middle managers in the purchasing function. Here, we build on the work of Drumwright (1994), who finds that "most [originators of environmental initiatives] were well-respected middle managers who had a claim to a hearing through some type of power" (p. 4). We define environmental pressure from middle management as the extent to which purchasing middle managers, in self-motivated and proactive ways, push their employer to improve the environmental standards in its supplier base. Partici-

pants from our survey pretest described different ways in which middle managers raise their concerns. They might regularly ask to put environmental supplier performance on the agenda of corporate sourcing committee meetings, ask to bring along environmental experts to supplier audits to identify gaps, and initiate working groups to develop multistaged measures that can help suppliers improve their performance (including consequent monitoring of progress and escalation mechanisms).

Stakeholder theorists suggest that middle managers wield influence over the firm because they are to a certain degree more difficult to replace than lower level employees. Specifically, middle managers constitute the link between the firm's executive management and the operational workforce. They possess certain strategic knowledge, and they play a crucial role in securing the trust of large parts of the employee base in the firm's management decisions (Frooman 1999; Arens and Brouthers 2001; Ehr Gott et al. 2011).

Our expectations about middle managers' influence on firms' environmental supplier development efforts are based on the tenets of social identity theory (Backhaus et al. 2002; Ehr Gott et al. 2011), suggesting that employees derive some of their self-esteem from their connection with their firm, including their firms' values and business practices (Dutton et al. 1994). Similarly, Kristof (1996) writes that employees' support of the firm is strongly determined by the congruence of their values with those of the firm. Consequently, when middle managers put pressure on the firm to act in an environmentally responsible way, buying firms are well served by responding with strong environmental efforts. Environmental supplier development can be seen as a fruitful form of response because it is a particularly proactive and resource-intensive initiative and thus signals the firm's value alignment with its middle management group. Hence:

H₃: *Middle management environmental pressures are positively related to environmental supplier development.*

OUTCOMES OF ENVIRONMENTAL SUPPLIER DEVELOPMENT

According to the RBV, a firm's ability to differentiate itself from and get ahead of the competition depends substantially on the organizational resources it possesses and the way it combines them (Wernerfelt 1984; Barney 1991). In particular, competitive advantage can be maintained if the firm's rivals have difficulty imitating or finding substitutes for the firm's resources (Barney 1991). Linking the RBV to a firm's environmental strategy, Hart (1995) introduces the "natural resource-based view," according to which environmental efforts give the firm unique, inimitable resource constellations. This inimitability arises when firm efforts comprise a rich and intricate (and to the outsider opaque) interaction of parties and resources. Sharma and Vredenburg (1998) propose resource categories that firms can develop through their environmental efforts when they involve complex organizational interaction, including technological and managerial capabilities, environmental firm reputation reflecting firms' standing with stakeholders, and organizational learning. We argue that environmental supplier development as one form of such complex environmental activities is positively associated with the suppliers'

strategic capabilities, including their technological and managerial skills (Vachon and Klassen 2008), from which the buying firm ultimately benefits as well. Also, environmental supplier development can be perceived as an extraordinary environmental commitment by the buying firm, and we expect such a commitment to positively affect the *buying firm's environmental reputation*. Finally, we argue that environmental supplier development can be a platform for substantial *organizational learning*, not only on the supplier side but also, particularly, for the buying firm itself.

Suppliers' strategic capabilities

Suppliers' strategic capabilities center on the longer term organizational characteristics of the firm's suppliers. Management quality (Stump and Heide 1996), financial stability (La Londe and Masters 1994), and technological capabilities (Monczka et al. 1995) can be seen as key reflections of these characteristics (Ehrgott et al. 2011). For the buying firm, understanding suppliers' strategic capabilities is critical because these capabilities determine the suppliers' capacity to innovate and remain competitive and thus to participate in a stable and longer term business relationship. Managers interviewed during our survey pretest described different ways in which buying firms confirm their suppliers' strategic capabilities. For example, in the regular supplier selection and monitoring processes, buying firms typically assess the development of key revenue and profitability performance indicators over the past several years, compliance with the latest ISO certifications, and reports of technological competencies and capacities (e.g., through supplier self-reporting instruments) as proxies for such capabilities.

We expect that investments in the development of suppliers' environmental standards positively affect the general strategic capabilities of these suppliers. Contrary to some types of supplier development (e.g., logistics-centered development projects that do not necessarily intervene in a broad way with the suppliers' production technology), upgrading a supplier's *environmental performance* often entails broader technological intervention. It typically requires helping the supplier use technologies and production processes that are more advanced and that specifically allow for improvements such as lower emissions footprints, more efficient energy use, and/or better waste management (Klassen and Vachon 2003). For example, BASF's eco-efficiency development project with emerging economy suppliers involved a systematic modernization of the suppliers' production systems; it started with an analysis of the suppliers' current status using BASF's proprietary diagnostic tools and included consulting on process and technological improvements throughout the suppliers' systems by BASF's production experts (UNIDO 2004). Both the outlined reasoning and the BASF example align with the contentions of the RBV. Specifically, Hart (1995) and Waddock and Graves (1997) find that adherence to high environmental standards often requires the development of superior management and technology resources, including advanced manufacturing technologies and efficient and tightly controlled processes. These resources allow not only for better environmental performance but also for higher product sophistication and innovation capabilities. Hence:

H₄: *Environmental supplier development is positively related to suppliers' strategic capabilities.*

Buying firm environmental reputation

We conceptualize the environmental reputation of the buying firm as the degree to which it is perceived as being environmentally sound by the market, that is, mainly by the firm's customers and industry-relevant media (the latter being, e.g., trade journals, industry reports, sustainability agencies, or any other communication informing the decision making of the firm's customers). Such a reputation for environmental concern and expertise represents a hard-to-imitate resource (Russo and Fouts 1997) and thus a differentiator from the competition.

Purchasing activities represent a significant part of firms' value chains, and for many companies, emissions and other environmental hazards created in the upstream supply chain (as well as resulting reputational risks) are far greater than those in the buying firm's own production. Of course, environmental supplier development does not necessarily lead to consistently high environmental standards across all of the buying firm's suppliers (given that supplier development programs typically address only part of a buying firm's supplier portfolio) (Bai and Sarkis 2010). Nevertheless, it still can have a positive effect on the buying firm's environmental reputation because the high resource commitments that are involved (Bai and Sarkis 2010) might allow the firm to be perceived as industry-leading in environmental engagement as well as to signal a strong commitment to environmental causes and the lowering of environmental risks in the supply chain. Empirically, Toms (2002) corroborates these expectations. Using a sample of 126 U.K. firms, he finds that environmental efforts are particularly effective for building an environmental reputation when they involve projects that competitors cannot easily duplicate, thus preventing them from making comparable claims about their own environmental performance. Similarly, Hasseldine et al. (2005) find that a firm's environmental reputation can be more effectively formed by a smaller number of complex, highly resource-committing activities than by a larger number of easier efforts. Because environmental supplier development closely matches this more complex activity profile, we hypothesize:

H₅: *Environmental supplier development is positively related to a buying firm's environmental reputation.*

Organizational learning in supplier management

We conceptualize the extent of organizational learning in supplier management as the degree to which the buying firm improves its ability to effectively cooperate, coordinate, and integrate with suppliers—in our case, from emerging economies (Carter 2005; Ehrgott et al. 2011). In other words, it describes the extent to which the firm is able to use its interactions with emerging economy suppliers to acquire better skills for generally managing the corresponding relationships. In the sense of March (1991) and Barney (1991), such learning occurs when knowledge

is accumulated over time and is stored by organizations in their procedures, rules, and social relationships.

Environmental supplier development efforts typically intervene with larger parts of suppliers' production technology (contrary, e.g., to joint logistics projects, which typically include much less of such intervention). Also, it typically requires that a relatively large number of experts from the buying organization (e.g., engineers from the production function and experts from the logistics and R&D units) spend significant time at the supplier's site. Schaefer and Kosansky (2008) and Paulraj (2011) argue that such a cross-functional collaboration is a key component of sustainable supply management. Moreover, environmental supplier development projects might allow the buying firm to understand its suppliers' mindsets beyond the mere transactional business context (e.g., beyond a mere awareness of typical quality- and contract-related specifics). In particular, the buying firm might have the opportunity to gain insights into the supplier's broader political and legal environment (e.g., into the local environmental regulatory requirements and societal expectations). For example, the environmental development project conducted by Pentland and Nike with smaller and medium-sized suppliers in Vietnam involved a complex partnership approach in which managers from the two multinational enterprises came together with local government partners, the local Chamber of Commerce and Industries, the International Leaders Forum, and the Mekong Development Facilities, among others, not only to help individual suppliers but also to discuss gaps between local regulation and internationally accepted standards (UNIDO 2004). This sort of intense interaction, in turn, allows the buying firm to enhance its familiarity with and confidence in emerging economy market environments and to gain insight into the processes, strengths, and weaknesses of the supplier. In other words, the buying firm builds skills that allow it to more quickly identify and react to the typical issues that arise when sourcing from business partners in emerging regions. Empirically, little light has been shed on the role of organizational learning as an outcome of environmental sustainability in the supply chain. In one of the few existing studies, Carter (2005) investigates purchasing managers and executives in U.S. consumer products manufacturing organizations and finds a positive link between environmental (and social) activities by the purchasing function and organizational learning. This corroborates our expectations about a positive link between environmental supplier development and organizational learning in the buying firm. Hence:

H₆: *Environmental supplier development is positively related to the extent of organizational learning in supplier management.*

METHODOLOGY

Sampling and data collection

To collect the study's empirical data, we used a mail questionnaire sent to a random sample of 1,500 U.S. companies and 1,000 German companies from the manufacturing, construction,

and retail industries (SIC codes 15–17, 20–39, and 50–59).¹ We chose these particular industries based on their high exposure to environmental issues. Firms had to have at least 50 employees and annual sales of at least USD 10 million. We used this criterion to ensure a focus on medium- and large-sized companies, which are more likely than small-sized firms to have direct relationships with emerging economy suppliers.

To define the scope of sourcing countries, we used a comprehensive list of emerging economies provided by the Forbes-accredited Euromoney Institutional Investor Company (Ehr Gott et al. 2011). Its database, "ISI Emerging Markets," identified 72 countries as emerging economies. We discussed this portfolio of countries in the preinterviews before the launch of our data collection. To accurately reflect the actual emerging supply markets relevant for U.S. and German companies, the purchasing managers participating in the pretest suggested some modifications to this country list. (See Appendix 1 for the resulting portfolio of 50 sourcing countries as it was presented to the respondents in the final questionnaire.) Analyses of the collected data show that, on average, 60% of the purchasing volume that the participating companies source from emerging economies was from Asia, followed by 30% from Eastern Europe, and 10% from Latin America.

Both U.S. and German respondents received an identical questionnaire in the English language. This approach was possible because the high-level position of the targeted key informants (and the job requirements of such a position) ensured that all survey respondents were proficient in English. Testing for measurement equivalence between the two country samples confirmed that understanding of the items and constructs did not differ between U.S. and German respondents. (See the Scale Development section for further details.)

We received 107 usable questionnaires from U.S. firms and 137 from German companies. Of the complete sample, 508 U.S. companies and 138 German companies either replied that they did not purchase from emerging economies or could not be reached because of invalid contact information. Reducing the sample by these figures resulted in an overall effective response rate of 13.2% (244/1,854). Appendix 2 provides an overview of the sample demographics.

Nonresponse bias

To ensure the robustness of the results against nonresponse bias, we performed two different tests. First, we conducted a multivariate *t*-test to compare the answers of early respondents with those of late respondents of our survey (Armstrong and Overton 1977; Wright and Armstrong 2008). We found no difference between early and late respondents. Second, we sent an abbreviated questionnaire to initial nonrespondents (Lambert and Harrington 1990). To ensure the highest possible number of responses, we also made follow-up phone calls. In total, we obtained 20 new responses and compared these with the original sample by calculating another multivariate *t*-test. No significant differences emerged between respondents and nonrespondents.

¹This sample resulted from the same data collection effort that is the basis of Ehr Gott et al. (2011).

Key informant issue

We addressed our survey to the respective purchasing heads of our sample companies. The existing literature suggests that higher level purchasing executives are key informants for surveys on global sourcing and sustainability topics (Carter 2005; Ehrgott et al. 2011) because these managers typically have detailed knowledge of sustainability standards in their firms' global supplier management and, at the same time, are able to judge both the various antecedents behind these efforts and the performance dimensions measured through the outcome constructs of our study. To ensure that respondents were actually knowledgeable, the questionnaire included an assessment of the respondents' ability to answer the respective scale items. It captured the respondents' experience in the purchasing function (in years), the degree of involvement in the firm's supplier management activities, and the level of involvement in the purchasing function's sustainability activities (the latter two measured on a Likert-type scale ranging from 1 for "somewhat involved" to 7 for "very involved"). Respondents' average experience in the purchasing function was 9.1 years, average involvement with supplier management activities was 6.2 on the scale, and average involvement with their firms' sustainability activities was 5.9 on the scale.

Common method bias

To reduce the risk of common method bias, items assessing the focal construct, "environmental supplier development," were presented first in the questionnaire, followed by items measuring the presumed antecedents, followed by the presumed outcomes (Podsakoff and Organ 1986). Each of these three sets of items was assessed in separate sections and on separate pages of the survey. We also employed the single-method-factor approach of Podsakoff et al. (2003) to test the data for potential common method bias. To this end, we added an additional latent construct to the structural model, to which all items in the model were connected as indicators. The addition of this construct did not make any previously significant paths insignificant or any previously insignificant paths significant. Thus, the test does not indicate a bias resulting from common method variance.

Scale development

The measures used in this study are based on existing scales, to the extent possible. However, all existing scales had to be modified to fit the emerging economy context of the study. The constructs covering environmental pressures from customers, the government, and middle management employees were based on the work of Carter and Jennings (2004). The focal construct—environmental supplier development—was based on Krause et al. (1998), Rao (2002), and Rao and Holt (2005). Operationalization of suppliers' strategic capabilities drew on a scale from Stump and Heide (1996), the scales used to assess the buying firm's environmental reputation and the extent of organizational learning were developed through a comprehensive literature review, as well as from interviews and pretests with purchasing managers and supply chain scholars (also see Ehrgott et al. 2011 who use the same scales for organizational learning in supplier manage-

ment and supplier strategic capabilities). All questionnaire items were measured on a 7-point Likert-type scale ranging from "strongly disagree" to "strongly agree." We pretested the survey with eight academics experienced in supply chain and sustainability research and with 11 supply chain managers, leading to adaptations in the wording of some items.

We conducted a confirmatory factor analysis (CFA) to establish our measurement model. After scale purification, we found an appropriate model fit with a χ^2/df ratio = 1.52, comparative fit index (CFI) = .97, Tucker Lewis index (TLI) = .97, goodness-of-fit index (GFI) = .90, adjusted goodness-of-fit index (AGFI) = .87, normed fit index (NFI) = .93, composite reliabilities greater than or equal to .84, and a root mean square error of approximation (RMSEA) = .046, all meeting the required thresholds (Bentler 1989; Browne and Cudeck 1989; Hair et al. 1995, 2006; Hu and Bentler 1999). Furthermore, each scale item had a factor loading of at least .40. All factor loadings were highly significant ($p < .0001$), suggesting convergent validity (Gerbing and Anderson 1988).

We assessed measurement equivalence across the U.S. and German samples by performing a two-group CFA with all factor loadings constrained to be equal across samples (Kaufmann and Carter 2006). None of the constraints was significantly different from zero ($p > .05$), and the chi-square difference between the unconstrained and constrained models was insignificant ($\chi^2 = 19.996$, $\text{df} = 16$, $p > .05$), suggesting measurement equivalence across the two samples. Appendix 3 provides an overview of the final scales and the respective measures of reliability and validity.

Control variables

We tested the robustness of our model by introducing five control variables: firm size, people-oriented organizational corporate culture, corporate environmental strategy, industry, and share of purchases from emerging economies. These variables have been identified by the existing body of literature as potential influences in sustainability contexts. Including these variables made no previously significant path insignificant and no previously insignificant path significant.

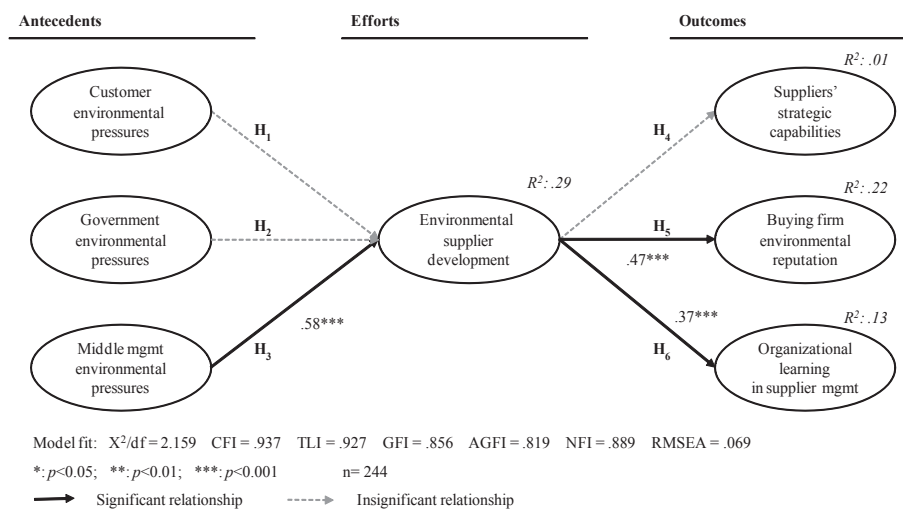
Stakeholders' perceptions of a firm may be influenced by the firm's size (González-Benito and González-Benito 2006). Larger firms may be better known and more observable, leading to heightened stakeholder attention. We use annual business unit sales as a proxy for firm size.

Because of differing resource requirements in the upstream supply chain, the relevance of environmental supplier development may vary between industries (González-Benito and González-Benito 2006). Correspondingly, awareness that buying firms (and their stakeholders) in different industries have of their suppliers' environmental standards may also vary. To control for such differences, we use a dummy industry variable.

Companies with higher purchasing volumes from emerging economies might show a comparatively higher probability of engaging in environmental supplier development because relationships with suppliers from these regions are more important to them. To test for such effects, we include the share of purchases from emerging economies as a control variable, mea-

Table 1: Correlations between constructs

Construct	1	2	3	4	5	6	7
Middle mgmt environmental pressures	1						
Government environmental pressures	.468	1					
Customer environmental pressures	.605	.550	1				
Environmental supplier development	.537	.229	.283	1			
Organizational learning	.196	.084	.103	.365	1		
Buying firm environmental reputation	.253	.108	.133	.471	.172	1	
Suppliers' strategic capabilities	.057	.024	.030	.107	.039	.050	1

Figure 1: Research framework and results of structural equation model.

Note: The antecedent constructs are defined based on Ehr Gott et al. (2011) but use separate survey items which operationalize these pressures as environmental, rather than social, stakeholder pressures. The suppliers' strategic capabilities and the organizational learning in supplier management constructs use the same data used by Ehr Gott et al. (2011).

sured as a percentage of total purchasing volume in U.S. dollars/Euros for the U.S. subsample and the German subsample, respectively.

When environmental sustainability is part of a firm's overall business strategy, middle managers might be encouraged to more explicitly push for environmental projects. For the same strategic reasons, however, the firm might also engage in environmental supplier development (Carter and Jennings 2004), potentially leading to endogeneity issues. We therefore control for the influence of environmental firm strategy using the item, "Our company makes environmental sustainability an integral part of its business strategy," on a 7-point Likert-type scale.

Similarly, a people-oriented organizational culture has been found to affect employee initiatives, as well as firms' conduct concerning environmental issues (Carter and Jennings 2004). To control for such an influence, we include a scale based on the work of Chatman and Jehn (1994) and Carter and Jennings (2004) with the following items: "Our company's organizational culture is strongly characterized by (a) being people-oriented, (b) fairness, (c) being supportive, and (d) the desire to be a good corporate citizen."

Structural model analysis

We tested our hypotheses through structural equation modeling (SEM). A power analysis to validate the adequacy of our sample size (MacCullum et al. 1996) revealed a power for close fit of .999 for both our measurement and structural models (at $\alpha = .05$ and alternate RMSEA = .08 and with underlying degrees of freedom [df] = 219 for the structural model and df = 207 for the measurement model). These values exceed the commonly accepted .8 threshold (MacCullum et al. 1996) and indicate sufficient statistical power to detect potential model misspecification.

In research using SEM, potential issues with multicollinearity need to be considered (Kaplan 1994). Grewal et al. (2004) show that effective testing for discriminant validity can largely screen out these issues. Following these authors' recommendation, we assessed discriminant validity by examining the average variance extracted for each construct and ensuring that it exceeded the squared correlations with all other constructs (Fornell and Larcker 1981). The criterion was fulfilled in all cases. Furthermore, we performed chi-square difference tests between a model in which a factor correlation parameter was fixed at 1.0 and the ori-

ginal unrestricted CFA model (Anderson and Gerbing 1988). A significantly worse fit exists for the study's restricted versus unrestricted models, also providing evidence of discriminant validity. The correlations among the study's latent constructs are shown in Table 1.

Figure 1 provides an overview of the results of the structural model and the measures used to assess model fit. All applied measures indicated a very satisfactory fit of the model to the data, with the $\chi^2/df = 2.159$, CFI = .937, TLI = .927, GFI = .856, AGFI = .819, NFI = .889, and RMSEA = .069.

To ensure the robustness of our results, we tested for potential differences between U.S. and German buying firms. We again used a multigroup analysis, with all paths constrained to be equal across samples. The chi-square difference between the unconstrained and constrained models was insignificant ($p > .05$), suggesting no difference in the results between U.S. and German respondents. We next discuss the implications of these findings.

RESULTS

Antecedents of environmental supplier development

One of the most noteworthy outcomes, shown in Figure 1, is the dominant role of internal stakeholder pressures, specifically, from *middle-level purchasing managers*, as an antecedent force of environmental supplier development initiatives (H_3). This result corroborates the predictions of stakeholder theory that middle managers can use their salience to influence the firm's supplier development practices according to their environmental expectations. Furthermore, these empirical results suggest that the firm can strengthen its bond with middle managers by recognizing and addressing middle management environmental values and expectations. Environmental supplier development apparently is chosen by firms as a specific effort to demonstrate such recognition, likely because it is a particularly proactive and resource-intensive initiative and can thus signal the firm's value alignment with its middle managers. This move appears especially plausible against the specific background of purchases from emerging economies. In these regions, environmental standards among suppliers are often lower than those in Western companies, and purchasing managers might thus be spurred to push strongly for improvements.

Pressures from *customers*, on the other hand, do not emerge as an antecedent to environmental supplier development (H_1). This evidence suggests that in cases where firms experience customer demands for environmental sustainability, they do not consider environmental supplier development to be an effective response for delivering on such demands. One potential explanation might be that firms evaluate possible responses to environmental customer pressures through a cost-benefit lens (McWilliams and Siegel 2001; Barnett 2007) and might conclude that environmental supplier development is not the most cost-efficient alternative when they are confronted with customer environmental expectations (e.g., compared to donations to environmental causes or acquiring environmental certifications).

Furthermore, our results show no relationship between *government* pressure and environmental supplier development (H_2), suggesting that firms do not consider environmental supplier development to be an effective means to deliver on government

demands for environmental sustainability. Firms might in fact recognize that they can change their supplier portfolios relatively easily at a later point in time, as an immediate response to regulatory changes (Ehrgott et al. 2011). The need for a proactive stance on government regulation would thus be lower than expected. That is, firms would not need to engage in costly environmental supplier development, but instead would switch to better suppliers when needed. Such switching is even likely to be relatively neutral in cost, on average, in emerging economies because Western firms still tend not to fully integrate with suppliers from these regions, but rather to source commodities or simpler components from them. Support for this view comes from Buysse and Verbeke (2003), finding a positive governmental influence only on environmentally reactive companies and not on environmentally proactive firms.

Outcomes

The most striking finding with regard to outcomes of the firm's environmental supplier development is the highly significant links between supplier development efforts and both buying firm environmental reputation (H_5) and organizational learning (H_6).

Apparently, environmental supplier development helps to build a positive *environmental reputation* as it is perceived as an extraordinary engagement that requires high resource commitments (Bai and Sarkis 2010) and demonstrates the buying firm's ability to manage complex environmental challenges in its upstream supply chain. Our finding thus supports the work by Hasseldine et al. (2005), suggesting that even a smaller number of high-involvement supplier development efforts apparently is able to augment the firm's environmental reputation.

Based on our empirical evidence regarding *organizational learning*, environmental supplier development efforts appear to, in fact, lead to sufficiently rich interaction between the purchasing department and suppliers, so as to generate strong learning effects for the buying firm. Environmental supplier development projects can require that many different experts from the buying firm be involved at the supplier site for extended periods of time (Carter and Carter 1998). As evidenced by the previously described examples of BASF, Pentland, and Nike (Bethke and Bluethner 2003; UNIDO 2004), environmental development projects in emerging economies allow for an exchange of thoughts beyond the usual business context, providing a broader perspective of the supplier's political, legal, and social context in the emerging region. This rich interaction gives the buying firm the opportunity to gain deep insight into the business practices of emerging economy firms and thus to enhance its overall ability to manage relationships with business partners from these regions.

In contrast, we did not find a relationship between environmental supplier development and *suppliers' strategic capabilities* (H_4). One explanation could be that the firm is not able to reach a sufficient number of suppliers with such development efforts to measurably affect the average capabilities of its supplier base (as measured in this study). This thought is supported by the work of Klassen and Vachon (2003), who do find a positive effect of collaborative environmental initiatives (e.g., supplier development initiatives) on supplier capabilities when they look at the individual suppliers involved in such initiatives rather than at the

buying firm's entire supplier portfolio on average. Alternatively, the effect that environmental supplier development (e.g., in the suppliers' energy use or production technology) has on the capability of the individual suppliers could be too small to be reflected in a measurable way in the higher level strategic capabilities of the supplier. Potentially, investments required to realize improvements of a measurable magnitude would be unattractive for the buying firm from a cost-benefit perspective and are thus not undertaken.

THEORETICAL IMPLICATIONS

Overall, the R^2 value of .29 for environmental supplier development indicates that *stakeholder theory* is a good lens for explaining antecedent forces influencing environmental supplier development. The dominant role of *mid-level purchasing managers* indicates that the relevance of internal stakeholders Ehr Gott et al. (2011) find for the social sustainability and supplier selection context can be similarly observed in the context of environmental efforts in the supply chain. This suggests that the prevailing focus the sustainability literature places on external stakeholders (Carter and Carter 1998; Deephouse and Heugens 2009) is to be expanded. In this, future research might address the question of what actually motivates the firm's middle managers to push so strongly for environmental supplier development. A fruitful starting point for such research could be the work of Carter and Jennings (2004), who found individual employee values to be a strong antecedent to sustainability initiatives in the purchasing function.

We did not find relationships between *customer* and *government pressures* and environmental supplier development, leading to two novel questions. First, do links exist between these groups and other forms of environmental engagement in purchasing? For example, firms might react to these pressures by engaging in less complex forms of environmental efforts such as donations to environmental causes or acquiring environmental certifications. Second, if higher levels of environmental customer and government pressures do not lead to significantly higher levels of environmental supplier development, a critical topic for future research is to explore what other antecedents are relevant—and why?

The literature on *organizational learning* in supply management contexts is still comparably embryonic and has so far focused on identifying outcomes of such learning processes (Hult et al. 2003). Our study complements this perspective by identifying a specific firm activity—namely, environmental supplier development—that can lead to organizational learning. In addition, in relation to Carter's (2005) finding that Purchasing Social Responsibility (activities comprising diversity, the environment, human rights, philanthropy, and safety) is related to organizational learning, and Ehr Gott et al. (2011) who find supplier selection involving social criteria to be one antecedent of organizational learning, our findings provide mounting evidence that organizational learning and supply chain sustainability are closely related and that organizational learning theory is a crucial lens when studying outcomes of environmental efforts. Hence, exploring a whole new set of questions appears worthwhile: Does the extent of organizational learning differ with the charac-

teristics of the supply markets? Which organizational factors moderate the learning process? How do characteristics of the purchasing managers moderate the learning effect?

Finding a relationship between environmental supplier development and buying firm environmental reputation (with the latter reflecting customer perception next to media and industry perception) lends support to Deephouse and Heugens (2009), Hietbrink et al. (2010), and Carter and Jennings (2004), who point to rising customer awareness of corporate social responsibility (CSR) issues in the supply chain. Interestingly, however, some scholars find contrary evidence in this regard. Particularly, Pomeroy and Dolnicar (2009) and Auger et al. (2003) argue for limited customer awareness of CSR issues in real-life (i.e., nonexperimental) settings. We recommend future research to further investigate this dissonance in findings and to more closely explore the contingencies under which customer awareness of sustainability activities, and particularly of environmental efforts in the supply chain, accrues.

Considering the broader *RBV literature*, there is a renascent discussion on the relevance of resource-based thinking in supply management contexts (Barney 2012; Hunt and Davis 2012). Priem and Swink (2012), for example, raise the question about the exact ways in which supply management practices can strengthen the firm's resource base. Our findings add to the debate for the specific case of environmental supplier development. On one hand, environmental supplier development does not seem effective in augmenting the average quality of the firm's supplier base (as a firm resource). On the other hand, environmental supplier development does lead to organizational learning and thus augments the firm's capability to integrate with supply chain partners from emerging economies. In this regard, our findings lend support to the arguments of Swink et al. (2007) and Chen et al. (2009), who write that having the ability to integrate the supply chain (i.e., to develop relation-specific organizational routines and knowledge) can be an important way by which the supply function contributes to firms' competitiveness.

MANAGERIAL IMPLICATIONS

The findings from this study hold three primary implications for management practice. Foremost, environmental supplier development proves to be an effective means of stimulating organizational learning in the purchasing function. It requires that purchasing managers interact closely with suppliers in emerging economy markets, as well as with various governmental and non-governmental stakeholders in those markets and with different functional areas and departments within their own firm. Thus, they are able to expand their awareness of critical issues in these supplier relationships. Admittedly, analyzing the complex network of constituencies and identifying those parties to be involved in the environmental supplier development effort is a complex task for management (Cantor et al. 2012). An approach that has proven useful for such tasks in the context of joint buyer-supplier projects is process mapping (Parsley 2011). With this method, the individual steps, decisions, and activities required to achieve the desired environmental improvement of the supplier are laid out and the interdependencies between them visualized. For each stage and element of the process, parties

with key responsibility, parties that need to be consulted, and parties that need to be informed are defined.

Second, environmental supplier development efforts can have positive effects on the buying firm's environmental reputation. Customers appear to value extraordinary environmental efforts like supplier development at a relatively high level and imagine firms engaging in such efforts to be particularly environmentally friendly. Firms that have environmental supplier development programs are thus well advised to actively communicate with their customers about them (e.g., by highlighting them in advertising material or as dedicated sections in their sustainability reporting). Our finding that firms seldom use environmental supplier development as a response to environmental customer demands suggests that the reputational benefits of such efforts have not yet been realized by many companies.

Finally, firms need to consider the influential role that purchasing middle managers have on environmental efforts in the purchasing function. Accordingly, a firm that wants to excel with regard to environmental efforts in its supply function is well advised to consider personal environmental awareness and engagement when recruiting or appointing new middle managers. For those purchasing middle managers who are already in the organization, but who lack experience with environmental projects, firms might consider providing dedicated training programs that focus on environmental concerns in purchasing and supplier management.

LIMITATIONS

Although our study sheds light on several antecedents and outcomes of environmental supplier development, we have focused our investigation on nonfinancial aspects. Specifically, we have not explicitly studied the financial costs and benefits of environmental supplier development. Notably, such cost-benefits can accrue both on the side of the buying firm and at the supplier. Incorporating such a perspective would allow for breaking new ground along three lines.

First, it would allow for insights into the degree to which the benefits of environmental supplier development outweigh the associated costs and for a comparison of the cost-efficiency of environmental supplier development with other forms of environmental supply chain efforts. For example, when striving to lower the emissions level in the upstream supply chain, firms might consider an array of possible levers beyond environmental supplier develop-

ment, including optimizing transportation logistics, switching to geographically more proximate suppliers, or switching to suppliers with efficient production technologies already implemented.

Second, it would contribute by shedding light on the yet largely unanswered question of how the buying firm and the supplier can share the costs and benefits of environmental supplier development for their maximum mutual benefit. Because such studies require detailed access to the buying firm's cost and revenue structures, a qualitative, case study-based investigation, rather than a large-scale survey, would likely to be a more suitable approach. A conceptual starting point for analyzing the costs associated with environmental supplier development might be the work of Krause and Wagner (2008), who discuss budgeting issues in supplier development and cost-sharing approaches between the involved parties. Research in this area can also be informed by the literature stream on cost-benefit sharing in other (often production efficiency-oriented) types of buyer-supplier collaboration, with the works of Lockström et al. (2010) and Riha and Radermacher (2009) serving as fruitful points of departure.

Third, a consideration of the financial costs and benefits of environmental supplier development would help provide insights on the direct link between sustainability and financial firm performance. So far, the search for such a relationship has yielded inconclusive results. McWilliams et al. (2006) and Schuler and Cording (2006) note that the large number of factors affecting financial performance make a measurable magnitude of such a link unlikely. A more suitable approach to determine the contribution of environmental supplier development to the firm's overall financial success thus appears to be a monetary valuation of the specific costs and benefits produced by these efforts. With buying firm environmental reputation and organizational learning in supplier management, our study points to two benefits that future research should consider in such valuation.

The use of a single informant might represent another limitation of our study. Although we assessed the adequacy of this approach previously, future research might still consider using multiple informants. Especially in investigating the relationship between environmental supplier development and buying firm environmental reputation, a study that validates our findings by assessing the two constructs through different respondents would be helpful, further ruling out the possibility of "wishful thinking" or social desirability. In addition, multiple informants might also be used to assess the buyer's versus the supplier's perspectives (e.g., Carter 2000).

APPENDIX 1

ALPHABETICAL LIST OF EMERGING SUPPLY MARKETS IN SCOPE (AS PRESENTED TO RESPONDENTS)

Eastern Europe			Asia		Latin America
- Albania	- Georgia	- Romania	- Bangladesh	- South Korea	- Argentina
- Armenia	- Hungary	- Russia	- China	- Sri Lanka	- Brazil
- Azerbaijan	- Kazakhstan	- Slovakia	- India	- Taiwan	- Chile

Continued.

Appendix 1: (Continued)

Eastern Europe			Asia		Latin America
- Belarus	- Kyrgyzstan	- Slovenia	- Indonesia	- Thailand	- Columbia
- Bosnia/Herzegovina	- Latvia	- Tajikistan	- Iran	- Vietnam	- Ecuador
- Bulgaria	- Lithuania	- Turkey	- Malaysia		- Mexico
- Croatia	- Macedonia	- Turkmenistan	- Pakistan		- Peru
- Czech Republic	- Moldova	- Ukraine	- Philippines		- Trinidad
- Estonia	- Poland	- Uzbekistan	- Singapore		- Venezuela

APPENDIX 2
SAMPLE DEMOGRAPHICS

Characteristic	U.S. subsample	German subsample
Number of responses	107	137
Average firm size in sales per annum	USD 6,659 M*	USD 6,734 M*
Average # of employees	17,357	21,901
% Electronic firms	12.1%	6.6%
% Automotive firms	13.1%	16.8%
% Chemicals, pharmaceuticals, oil and gas firms	15.9%	11.7%
% Mechanical engineering firms	18.7%	19.0%
% Consumer goods firms	19.6%	24.8%
% Wholesale and retail trading firms	4.7%	6.6%
% Other firms	15.9%	14.6%
Average import ratio from emerging economies	23.46%	29.19%

Note: *Converted into U.S. dollars using EUR-USD exchange rate at the time of survey.

APPENDIX 3
QUESTIONNAIRE SCALE ITEMS^{a,b,c}
Customer Environmental Pressures

Our customers...

...set high environmental standards in their buying decision. (.94)

...show strong awareness about environmental issues. (.94)

...prefer purchasing from companies with a strong environmental image. (.91)

...inform themselves about their suppliers' environmental standards before buying from them. (.86)

Composite Reliability: 0.93, Cronbach's Alpha: 0.93, AVE: 0.772

Eliminated item (reason for elimination):

...are likely to switch to our competitors if these outperform us in environmental aspects. (high internal correlation)

Government Environmental Pressures

Government/legal regulation in our industry...

...currently sets strict environmental standards. (.88)

...is likely to increase pressure if our industry does not improve environmentally by itself. (.92)

...actively pushes for environmental improvement. (.94)

Composite Reliability: 0.90, Cronbach's Alpha: 0.90, AVE: 0.761

Eliminated items (reason for elimination):

Continued.

...is expected to increase pressure regarding environmental efforts within the next three years. (high internal correlation)

...is lobbied by activist groups to increase environmental standards. (high internal correlation)

...currently holds my company responsible for the environmental impact of our suppliers. (low factor loading)

Middle Management Environmental Pressures

The middle managers in our purchasing organization...

...show a personal sense of obligation towards environmental conduct. (.91)

...want our company to be perceived as a leader in terms of environmental responsibility (e.g., by the public, customers, media, etc.). (.91)

...speak up if they feel our company can improve environmentally. (.90)

Composite Reliability: 0.89, Cronbach's Alpha: 0.89, AVE: 0.738

Eliminated items (reason for elimination):

...have started projects to enhance our company's environmental performance. (high internal correlation)

...show initiative to advance environmental causes. (high internal correlation)

Environmental Supplier Development

With regard to our existing portfolio of suppliers from emerging economies, we...

...advise them on technology that makes their production cleaner. (.89)

...make efforts (e.g., joint projects) to show them how they can reduce waste in manufacturing. (.95)

...make efforts (e.g., joint projects) to show them how they can use resources more efficiently. (.94)

Composite Reliability: 0.92, Cronbach's Alpha: 0.91, AVE: 0.785

Eliminated items (reason for elimination):

...encourage them to continuously improve their emission levels (e.g., air or water pollution). (low factor loading)

...commit resources to coach them on employing reusable packaging solutions. (high internal correlation)

...continuously ask them to commit to waste reduction goals. (high internal correlation)

Suppliers' Strategic Capabilities

Averaging over our total purchasing volume from emerging economies, our current suppliers from these regions show...

...high technical capabilities. (.85)

...financial strength. (.80)

...good personnel and management resources. (.80)

...high innovation capabilities. (.85)

Composite Reliability: 0.84, Cronbach's Alpha: 0.84, AVE: 0.576

Buying Firm Environmental Reputation

Our company...

...is perceived as a leader in terms of environmental responsibility by our customers. (.89)

...is often referred to as a role model for environmental business practices by the media. (.91)

...is seen as an innovator regarding environmental business practices in our industry. (.92)

Composite Reliability: 0.89, Cronbach's Alpha: 0.89, AVE: 0.738

Eliminated items (reason for elimination):

...is the preferred provider for customers who care about environmental issues. (high internal correlation)

...has won awards for environmental merits. (high internal correlation)

Extent of Organizational Learning in Supplier Management

Interacting with suppliers from emerging economies enabled us to...

...develop skills to effectively coordinate with suppliers from such regions. (.84)

...develop expertise to manage suppliers from such regions. (.90)

...gain expertise that we can use across different countries in these regions. (.69)

Composite Reliability: 0.85, Cronbach's Alpha: 0.86, AVE: 0.649

Eliminated items (reason for elimination):

...learn more about doing business in these regions. (high internal correlation)

...gain insights that are also useful for other functions of our firm. (high internal correlation)

Fit indices overall measurement model: $\chi^2/df = 1.52$; CFI = 0.97; TLI = 0.97; GFI = 0.90; AGFI = 0.87; NFI = 0.93; RMSEA = 0.046.

Notes: AVE, average variance extracted.

^aStandardized factor loadings in parentheses.

^bAll items were measured on a 7-point Likert scale where 1 = *strongly disagree* and 7 = *strongly agree*.

^cRespondents were told, "This survey is targeted at companies that purchase from emerging economies." (The country list as shown in Appendix 1 was provided at the end of the questionnaire.) They were instructed: "You should only continue if your company buys part of its total purchasing volume, including direct material, indirect material, and/or machinery & equipment, from emerging economies (suppliers' shipping plants should be located in these regions)." Furthermore, they were asked "If your company has more than one business unit, please answer all questions with regard to your business unit only."

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SHORT BIOGRAPHIES

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Managing the Innovation Adoption of Supply Chain Finance—Empirical Evidence From Six European Case Studies

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Logistics' contribution to corporate performance has increased over recent years, particularly due to supply chain innovations. Opposed to common innovations focusing on the improvement of product or information flow, supply chain finance (SCF) targets the financial flow and allows buying firms and their suppliers to improve working capital and reduce costs. However, the adoption process of SCF is complex and rather unexplored in academia. This article provides an early step in building knowledge about SCF and in particular how firms adopt SCF, why they adopt differently, and what role suppliers play in the adoption process. The objective was therefore to close the gap between our knowledge on product and information flow oriented innovations and financial flow innovations along the supply chain, namely SCF. For this explorative research, we opted for an inductive multiple case study approach with six European firms. Based on our findings, four sets of propositions are posited and an extended SCF adoption framework is proposed revolving around the interrelated adoption processes of buying firms and their corresponding supplier bases.

Keywords: supply chain finance; innovation adoption; upstream innovation; case studies

INTRODUCTION

It is widely acknowledged that superior logistics management is a crucial driver of firm performance (Ellram 1991; Bowersox and Closs 1996; Mentzer et al. 2004; Fugate et al. 2010). Several innovations such as bar codes, radio frequency identification, cross-docking, and just-in-time delivery helped to grow the strategic impact of logistics management. Each of these innovations supported specific firms to outcompete competitors, with prominent examples such as Walmart, Zara, Amazon, Toyota, and Dell (Chopra and Meindl 2012). The scope was traditionally limited to managing physical inventory and information flows, whereas paying less attention to innovations in the third logistical flow, the financial flow of supply chains.

Lately, we have seen several firms tapping into the field of supply chain finance (SCF) as practitioner reports show (Aberdeen Group 2006, 2007; Demica 2007). In such reports, it is claimed that even one of seven firms actively uses SCF (Aberdeen Group 2007), as the need to harmonize financial and physical flows in European supply chains has been substantial, even already before the financial crisis (Castillón and Petit 2008). SCF provides a pathway not only out of short-term liquidity dilemmas but also toward a reduction in the long-term financial burden in the supply chain represented, for example, by the total amount of necessary liquidity in a supply chain. The necessary liquidity is lower with a coordinated financial flow across the supply chain than in the uncoordinated case (Protopappa-Sieke and Seifert 2010), especially leading to high savings when buyers and suppliers have different credit ratings (Pfohl and Gomm 2009).

Only recently, scholars also started to emphasize the importance of managing financial flows along supply chains (Bowersox and Closs 1996; Mentzer et al. 2001; Hofmann and Kotzab 2010; Gupta and Dutta 2011) and to address research topics with adjacent focus, for example, Protopappa-Sieke and Seifert (2010) on the interrelation of operational and financial performance measures in inventory control. Likewise, Hofmann (2009) studies inventory financing from a logistics service provider perspective and Pfohl and Gomm (2009) and Gomm (2010) review and conceptualize different approaches of financing supply chains. A conceptual approach is also provided by Hofmann and Kotzab (2010) who study collaborative working capital management and particularly cash management in supply chains. However, empirical knowledge about this new phenomenon of SCF is nascent, which can be explained by the mere fact that the SCF innovation only recently emerged and empirical research can only analyze existing practices and phenomena.

In practice, the innovation of SCF is considered to be an established structure founded on an agreement between a buying firm with its bank, stating that any supplier whose invoice has been released by this buying firm can obtain a credit from the bank for the period of the payment terms against the buying firm's credit rating (e.g., Demica 2007). This process is often automated through an electronic platform providing all involved parties with real-time visibility into the relevant financial transactions. Particularly in Europe, SCF offers some innovative aspects opposed to related practices such as reverse factoring, which are intensively used in emerging economies (Klapper 2006). Figure 1 illustrates the differences of a transaction without and a transaction including SCF indicating also the novelty of the process. This figure depicts the basic mechanism of SCF as we analyze it in this article. As we shall discuss in more detail along the case analyses, there are some differences among buying firms regarding the SCF implementation. For instance, buying firms may prioritize cash flows over automatization by focusing rather on the extension of payment terms. Another firm might prioritize the provision of flexibility to its suppliers and provide them with

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more transparency concerning the attainable short-term credit lines also allowing them to lend only fractions of the outstanding invoice volume. These differences are often manifested through the implementation of SCF; for instance, a buying firm might integrate the SCF platform into its enterprise resource planning (ERP) system or rather use a bank's website for each transaction. To be clear, although scholars conceptualize further aspects of SCF (e.g., Pfohl and Gomm 2009; Hofmann and Kotzab 2010), we focus on this specific type of SCF implementation as this is the most prevalent approach in practice. This enables us also to limit the domain of our research in such a way that the units of analysis are comparable. In the closing section of this article, we suggest how the findings of this specific approach are connected to different ways of managing financial flows along the supply chain.

The numerical example in Figure 1 illustrates the available benefits to both parties. In this case with an interest rate spread of 5.5% between the supplier and the buyer, SCF can reduce the capital costs for the supplier by 25% and lead to an additional saving of 50% in respective capital on the buyer side. Pfohl and Gomm (2009) come to similar conclusions in their conceptual work, but with a stronger focus on the risk reduction mechanisms available from adopting SCF in a broader sense. It can thus be concluded that the financial benefits available from SCF motivate its spread even though its adoption and implementation is complex and organizationally challenging (Seifert 2010).

Besides these valuable insights into the mechanics and advantages of SCF as well as adjacent practices, it appears that literature has so far overlooked the organizational perspective of implementing SCF, in particular, the SCF innovation adoption process. Even though new concepts do not as such automatically qualify as innovation, it can be concluded from extant innovation research that the concept of newness is considered the common

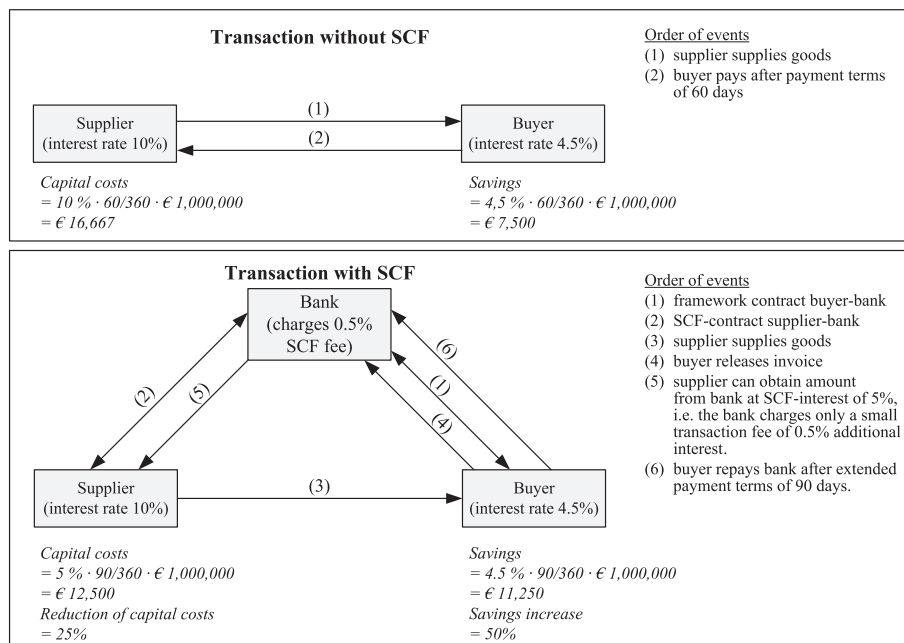
denominator of the wide array of definitions available for the term “innovation” provided in the scholarly community. Thus, we define innovation as “any idea, practice, or material artifact perceived to be new by the relevant unit of adoption” (Zaltman et al. 1973, 8).

In the domain of innovation management, it is common to distinguish between product and process innovations (Johannessen et al. 2001). As SCF is a new way of organizing the financial flows along the supply chain that does not affect the tangible product among supply chain partners as such, it qualifies as process innovation. Moreover, SCF has a significant effect on the unit of adoption, namely the buying firms and their suppliers, as SCF processes undergo a considerable adjustment during the innovation adoption process; therefore, the buying firm becomes the level of analysis in our study.

Furthermore, SCF reveals a unique upstream dissemination challenge toward suppliers as opposed to the landmark supply chain innovation literature typically focusing downstream innovations toward (end-) customers (e.g., Flint et al. 2008). The main difference lies between a buying firm that markets an innovation to its suppliers and one that markets an innovation to its customers, as we will discuss in detail in the conceptual framework. Thus, an upstream focus seems inevitable to understand the SCF adoption process from an innovation perspective. Hence, in this research we seek to contribute to the hitherto limited insights on the coordinated management of financial flows in the field of logistics and on the implementation of SCF from an upstream buying firm perspective in particular, and to upstream innovation literature in general.

For academia and practice, the adoption of financial logistics innovations is new. Therefore, we use an explorative multiple case study approach to build knowledge on how firms manage the SCF adoption process. This approach allows us to gain multi-

Figure 1: Supply chain finance (SCF) mechanism contrasting (A) transaction without SCF and (B) with SCF. Numbers are an illustrative example.



faceted perspectives that are necessary to understand the complexities of the innovation adoption process. In particular, we address the following research questions:

- How do buying firms adopt the SCF innovation?
- Why are certain firms more effective during this innovation adoption process?
- How is the upstream supply chain involved in this innovation adoption process?

By addressing these research questions, we make several contributions to research and practice. First, we provide in-depth insights into the adoption of the innovative SCF process which also provides further insights into upstream innovation diffusion processes, highlighting necessary adjustments to the influential innovation adoption framework of Rogers (2003) to account for the specificities of upstream innovations. Practitioners can gain know-how on the SCF implementation process from an internal and an upstream supply chain perspective reducing uncertainty on how to implement SCF. Finally, we provide an empirical contribution to the emerging field of research on the interface of logistics and finance.

The remainder of this article is structured in six sections. First, we present the literature review on SCF and (upstream) innovation adoption, concluding with our research framework. Subsequently, we describe our multiple case study method. Next, we present the results of our cross-case analysis based on which we developed testable propositions extending our initial research framework. We conclude the article by discussing its theoretical and practical implications, pointing to its limitations and suggesting paths for further research.

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

Two literature streams inform our research: (1) literature on the logistics and finance interface and (2) relevant literature on up- and downstream innovation management and organizational innovation adoption.

SCF can be localized in the literature stream on the interface between logistics and finance, which only recently gained increased attention (Gupta and Dutta 2011). Most research has thus far focused on conceptual work. For instance, Gomm (2010, 135) defines SCF as a process “optimi[z]ing the financial structure and the cash-flow within the supply chain,” whereas Grosse-Ruyken et al. (2011, 15) follow Camerinelli (2009) and Pfohl and Gomm (2009) in defining SCF as “an integrated approach that provides visibility and control over all cash-related processes within a supply chain.” Our definition takes an upstream supply chain perspective and focuses on the organizational structure to be implemented between the involved parties to achieve visibility and control and to recurrently take cash flow optimizing actions as outlined by the definitions presented above.

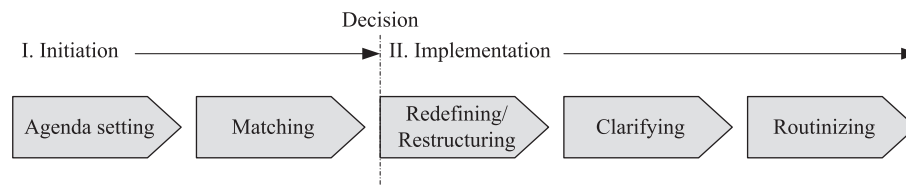
Even though we tackle an empirical research phenomenon there has been a rise in formal analytical modeling papers informing our research on the logistics and finance interface (e.g., Buzacott and Zhang 2004; Berling and Rosling 2005; Cal-

dente and Chen 2009). For instance, Protopappa-Sieke and Seifert (2010) analyze the interrelation of financial and logistics decisions within a supply chain indicating that improved upstream cash flows may reduce suppliers’ financial constraints and thus improve physical flows. In addition, Shang et al. (2009) study coordination schemes within supply chains and state that SCF platforms provide the technology of applying such coordination mechanisms indirectly affecting logistics performance. Although these models indicate that SCF has further benefits besides pure reductions of capital costs, they do not reveal insights on how the SCF innovation can be established and disseminated by the buying firm. Hence, our article focuses on a hitherto unexplored aspect of SCF.

The second stream informing our research on innovation adoption dates back to Ryan and Gross (1943) revealing that individuals face an innovation-adoption process consisting of several stages of decision making (Ettlie 1980; Rogers 2003). According to enhancements of these models, organizational innovation decision units must complete sequential process stages to finally adopt an innovation (Meyer and Goes 1988; Rogers 2003). Analyzing innovation decisions along such frameworks has several merits. In particular, by analyzing these stages separately, it resolves the problem that some structural variables, such as centralization and organizational slack, may have a positive as well as negative impact on the innovativeness of a firm (Rogers 2003). Furthermore, such models help to classify organizations in more detail than by purely building upon the distinction of adopters versus nonadopters (e.g., Meyer and Goes 1988; Fichman and Kemerer 1997). Therefore, in principle, such models also inform the SCF adoption process. Particularly, the frequently cited Rogers (2003) framework as depicted in Figure 2 appears to serve as an appropriate foundation for structuring our research, as it is generic enough to be transferred to SCF, but specific enough to show how stages are interrelated, even though it addresses predominantly organizational innovations opposed to the upstream innovation in our case of SCF.

Moreover, the framework does not require the research team to distinguish the degree of newness of SCF to the buyer and its suppliers. The SCF concept might be initially new to the buying firm and to early adopting suppliers, yet as the buying firm reaches the routinizing stage (see Figure 2) and more suppliers adopt SCF, the degree of newness to the buying firm decreases until it becomes an established structure of buyer–supplier relationships. Still, in the routinizing stage, the SCF innovation may be new to late-adopting suppliers that board on to the already established SCF platform of the buying firm (cf., Johannessen et al. 2001).

Nevertheless, it is important to highlight the specificity of the SCF innovation adoption by presenting to what extent findings from previous innovation research streams are or are not transferable to the SCF context. First, most of the innovation adoption models were designed and tested in a within-firm context without considering the upstream buyer–supplier interfaces (Meyer and Goes 1988; Ettlie and Reza 1992; Rogers 2003). Still, a specific stream of research focused on the benefits available from managing business processes across entities of the supply chain for faster product innovations, also termed design chain management (e.g., Twigg 1995), or supplier involvement in new product development (NPD) (e.g., Van Echtelt et al. 2008). Authors in

Figure 2: Innovation adoption stage model adapted from Rogers (2003, 421).

this field identified collaboration between developers of buyers and suppliers to be a particular driver of innovation project success. Although these findings inform our research, the involvement of suppliers in NPD is distinct from the involvement of suppliers in the SCF adoption as in the case of NPD the focus is still placed on downstream innovations. Supplier involvement in NPD directly affects the value of the product received by downstream customers, whereas SCF does not directly affect customer value as it does not lead to adaptations in the product properties or the production processes (Cooper and Kleinschmidt 1995; Mills et al. 2004). Regardless of the targeted direction of the innovation along the supply chain, there seem to be modes of mutual adjustment in the configuration of interorganizational NPD relationships that inform our research (cf., Bensaou and Venkatraman 1995; Ragatz et al. 1997).

Second, previous innovation adoption studies with the focus on the downstream dissemination of product or process innovations (Kim 2000) often took a perspective from the innovator to the customer (Cooper and Kleinschmidt 1995; Menor et al. 2002). Consequently, the innovator should take the actions of customers as target adopters into account. The particular merits for innovation project success of early customer involvement in downstream-focused innovation projects have been proclaimed, among others, by innovation management scholars (e.g., Neale and Corkindale 1998; Gruner and Homburg 2000). However, having established that the innovation dissemination does not lie downstream but upstream in the supply base of the buying firm (the innovator), knowledge on customer involvement might be partially applicable when involving suppliers (e.g., Kaulio 1998; Kärkäinen et al. 2001), but is not seamlessly transferable to the SCF adoption context due to the different roles of customers and suppliers in the supply chain setting. Thus, SCF is a specific innovation where the direct suppliers of the buying firm actually become the “target customers” or “target adopters” of the process innovation. The adoption process of the buying firm cannot be completed without a substantial proportion of its suppliers also adopting SCF. Therefore, the decision is not only to be made within an isolated organization, but rather between the buying firm and its supply base.

To conclude, we decided to equally take up- and downstream dissemination research into account while gaining field data to extend the Rogers (2003) framework of innovation adoption for our specific case of SCF. In particular, the Rogers framework serves as a starting point for our analytic case selection because it enables us to structure the multiple process steps of innovation adoption decisions from the buying firm’s perspective. During the cross-case analysis, adaptations to the model will be made where necessary, in particular, when it comes to supplier interaction.

CASE STUDY METHOD

With this study, we seek to understand the adoption of the innovative SCF process, which bears yet unexplored mechanisms such as the role of upstream supply chain members and functional collaboration between finance and logistics/procurement. In accordance with the purpose and research questions we posed, we opted for a qualitative multiple case study approach as research on *how* firms adopt SCF innovation is still in an exploratory stage and the adoption is complex in nature as multiple functions are involved (Eisenhardt 1989b; Ellram 1996; Meredith 1998; Wacker 1998; Gibbert et al. 2008; Yin 2009; Barratt et al. 2011).

Study design

The SCF innovation adoption process is our unit of analysis as all three research questions revolve around the SCF adoption from a buying firm’s perspective. Thus, we collected information from buying firms which are our level of analysis.

Following the advice of Gibbert et al. (2008) and Yin (2009) we accounted for construct validity, internal validity, external validity, and reliability throughout our research process (see Table 1). For instance, initially we interviewed key informants from logistics, procurement, and finance because the adoption of SCF often involves cross-functional teams consisting of these functions. Building upon their responses, we requested further interviews until we felt that we collected sufficient data in each organization as additional interviews would not reveal further relevant data. This approach increased construct validity and internal validity, as it enabled us to triangulate different opinions and thus to reduce biases. In total, 28 interviews were conducted.

Moreover, we used different data sources. Besides conducting at least 45–90 min long semi-structured interviews by the same research team, we used questionnaires, secondary external data such as trade publications or archival data, and focus group meetings. These additional data sources were necessary to understand the firm-specific SCF approaches and helped to obtain a realistic image during the data analysis—for instance, in the intra-case analysis as summarized in the Appendix. In this way, we opted for increased construct validity (Gibbert et al. 2008; Yin 2009). Further techniques are summarized in Table 1.

Case selection and data collection

Following Seawright and Gerring (2008) as well as Eisenhardt (1989b), we used a two-step approach of analytical sampling. First, we tried to obtain a rather homogeneous empirical target group with respect to size (only large firms), business activities (only production firms), and origin (Europe) as they all face comparable

Table 1: Validity measures

	Design	Case selection	Data gathering	Data analysis
Construct validity	Building questions on research framework derived from innovations literature No questions asked, which involve broad speculation	Not applicable	Multiple sources: Questionnaires, semi-structured interviews, databases, and reports Tandem interviews whenever possible to reduce biases Confidentiality and anonymity ensured	Data triangulation based on independent sources Data analysis in parallel to interview phase to be receptive to new results (Eisenhardt 1989b)
Internal validity	Research framework derived from well-established related innovation diffusion literature (Rogers 2003)	Not applicable	Multiple respondents Most knowledgeable key informants for SCF interviewed	Pattern matching among cases and model building Active search for alternative explanations Theory triangulation with diffusion of innovation literature
External validity	Comparative multiple case studies	Analytical sampling and inclusion of nonadopters to reduce pro-innovation biases (Abrahamson 1991)	Gathering data on the case context	Consideration of case context (Johns 2006) Extensive intra-case analysis (Eisenhardt 1989b) Pattern matching rather than statistical projections used (Gibbert et al. 2008; Yin 2009)
Reliability	Case study protocol according to Yin (2009) Case study database (including observations and transcripts)	Selection criteria well documented in case study protocol, i.e., replication is possible	Semi-structured interview guidelines reported in case study protocol All interviews transcribed by interviewers	Independent researchers followed Strauss and Corbin (1990) approach and discussed until convergence of interpretation was reached

Notes: References state where we adopted our procedure from. SCF, supply chain finance.

economical and regulatory environments and maturity of financial markets. Focusing on large firms is particularly appropriate when practices are new (Koufteros et al. 2007); especially as small firms would unlikely aim for automated SCF payment solutions, rather large buying firms have so far implemented SCF. Finally, small and large firms face distinct organizational challenges and thus it seems necessary to limit the sample to firms of similar size.

Second, our aim was to identify firms which are in different stages of the adoption process to better understand particular challenges in the adoption process. The aforementioned Rogers (2003) framework provided us general guidance on the critical dimensions for our sampling strategy. So, we deliberately avoided having only firms which reached the routinizing stage of SCF adoption and opened our sampling to firms which are in earlier stages of the adoption process. This decision may appear to be a small drawback in the later analysis as only few firms had fully adopted SCF to provide insights into the final stages of the adoption process. But, in fact, we compensated for this drawback by studying the two full-adopter cases in-depth, which is reflected by the high number of interviews (12 out of 28) in those two firms.

We chose this case selection strategy for three reasons: First, it reduces the pro-innovativeness bias (Abrahamson 1991). As

previous studies pointed out, analyzing only successful adopters shades an overly optimistic light onto innovations (Abrahamson 1991). Second, as with all innovations there is a steep learning curve in SCF. This means that certainly re-innovations have occurred since the first adoption (Rogers 2003). Therefore, including only those firms which have fully adopted would imply capturing a state of the innovation dating years back. And third, we witnessed that it is not impossible to obtain information regarding initial decisions from firms having fully adopted SCF. However, those firms which undergo the particular decision process at the very moment of data collection are better able to provide detailed, multifaceted insights which enhance the validity and reliability of collected data.

We subsequently added more companies to the sample until theoretical saturation was reached as further cases would have added only marginal insights (Strauss and Corbin 1990). In adding further cases we followed Strauss and Corbin (1990) as we selected new cases according to the criteria described above, but also tried to identify cases which appeared to be the most interesting according to our tentative data analysis up to that point. For instance, our analysis indicated that supplier involvement is an important aspect of the redesigning phase. Therefore, we included a company whose reputation is to collaborate closely

with suppliers in other processes, and in fact we also found that this company is engaged in supplier involvement, providing us valuable insights. For an overview of the individual cases and their characteristics, please refer to Table 2 and Appendix. As we promised anonymity to interviewees, we replaced company names by Greek letters. Furthermore, we generalized job titles of interviewees into the categories “logistics manager,” “procurement manager,” or “finance manager.”

Coding

Our data analysis approach was based on Strauss and Corbin (1990), as we used codes grounded in data. In this step, we integrated data obtained from all data sources discussed above (Moran-Ellis et al. 2006). However, as concepts from related research emerged, we adapted these (e.g., trust) to relate our findings with previous research (Eisenhardt 1989b; Mello and Flint 2009; Yin 2009). Then, we pursued axial coding (Strauss and Corbin 1990) by grouping codes into categories and trying to match patterns among the cases (Yin 2009) to also causally relate these categories.

Finally, we selected those relationships which reveal the most interesting insights with respect to SCF for further analysis. In this step, we challenged observations with existing theory (e.g., Van de Ven 1986; Rogers 2003; Benton and Maloni 2005). During the whole analysis, we constantly iterated between these three steps to probe the hypothesized relationships with actual data to ensure that the higher level of abstraction remains empirically valid. So, whenever necessary, we adjusted the tentatively assumed relationships. To illustrate our coding procedure, we state explicitly how we coded the categories throughout the first part of data analysis. However, for brevity we excluded these details in later stages of the article.

Data analysis

Having established the specificities of the SCF adoption in the literature review, we will now outline the SCF particularities of

our cases along Rogers' (2003) framework of organizational innovation adoption and refer to the Appendix for an intra-case description. We will shortly address the initiation and decision process to provide the whole background of our analysis, although our analysis particularly focuses on the implementation stage of the model (c.f., Table 3; Figure 2).

Initiation of and decision on SCF adoption

Progress in the initiation phase consisting of agenda setting and matching (Rogers 2003) is predominantly explained by three major categories, as our coding of interview statements reveals. In particular, we coded reasons as follows: *Organizational culture* (e.g., “I would see us as a very traditional company.” firm Alpha), *uncertainty avoidance* (e.g., “We are not sure, whether SCF would really fit in our case. We would need to see more successful cases first,” firm Beta), and *lack of top management commitment* (e.g., “Other working capital projects got CEO attention; SCF, however, did not,” firm Beta). Both nonadopters (Alpha and Beta) clearly show that their corporate culture is shaped by tradition and continuation rather than a strong posture toward innovative business models. In contrast, the firms already implementing SCF (Gamma, Delta, Epsilon, and Zeta) are rather innovative with lower risk aversion and strong top management commitment for innovations.

The initiation of SCF shows similar diffusion patterns to other studies analyzing organizational innovations. Buying firms need to have certain generic strategic priorities to be interested in SCF innovation (Rogers 2003). For instance, we learn that firms need to focus on working capital improvements and stable supply chains simultaneously. Similar to previous organizational innovation studies the adoption decision process incorporates top management (Alexiev et al. 2010) and advice from cross-functional teams (Miron-Spektor et al. 2011). Furthermore, we learn that behavior of competitors serves as indication of the opportunities inherent to SCF leading firms to imitative behavior (Semadeni and Anderson 2010). Although this process is slightly different in each organization (Sydow

Table 2: Case demographics and stage relative to innovation-decision framework by Rogers (2003)

Cases	Alpha	Beta	Gamma	Delta	Epsilon	Zeta
Industry	Coatings	Aviation	Chemistry	Pharmaceutical	Chemistry	Automotive
Country	Netherlands	France	Switzerland	Switzerland	Germany	Germany
Size	Large	Large	Large	Huge	Huge	Large
S&P's rating	BBB+	BBB+	BBB–	AA–	A–	A–
First exposure to SCF	2010	2009	2009	2009	2008	2006
Highest management level involved	Not applicable	Head of SC	CPO	CEO	CEO	CEO
State	Initiation	Initiation	Implementation	Implementation	Implementation	Implementation
Stage	Matching (awareness)	Matching (potentially rejecting)	Restructuring/ redesigning (evaluation)	Restructuring/ redesigning (piloting)	Clarifying (on-boarding of suppliers)	Routinizing (continuing)
# interviews logistics	1	1	1	1	1	1
# interviews procurement	1	1	2	1	3	2
# interviews finance	1	1	3	2	3	2

Table 3: Quotes, codes, and categories derived from observations

Category	Codes	Original quotes
Redefining (to upstream SC needs)	Benefits allocation mechanism	“Although the economic idea is the same in different SCF solutions we considered, they all differ in details. [...] In the beginning, our priority was to find a solution that best fits our needs.”
	Degree of automation	“The system is very well integrated. [The supplier] uploads all required information to the platform and we import these settings and simply ‘flick a switch’ in our ERP system.”, “Suppliers have no longer issues with reconciliation as they always have real time transparency whether we have released their invoices. Once we have done so, they are informed automatically and can decide themselves when to get paid.”
	Scope of suppliers	“We segment our suppliers and only target strategic or crucial ones. We do not intend to onboard any leverage or opportunistic suppliers.”, “As soon as the system was in place, we tried to get as many suppliers on board as possible. However, those with an annual spend below € 200,000 are not interesting for our set-up. [...]”
Restructuring	Cross-functional collaboration	“We met weekly to discuss operational issues and twice a month with the whole SCF team.”, “We needed to work very closely with our colleagues from finance and still have formal weekly meetings.”, “At the moment, we have a leadership team and we discuss strategic SCF issues directly on top management level”, “It is crucial to integrate operational—not only strategic—procurement managers from the start on to have better, immediate feedback from those who will work with the system.”
	Job design	“Upstream supply chain managers initially said: ‘Procurement managers initially said, it is not our task to use SCF, it is not in our working contracts and job description. We do not want to implement SCF’”
	Performance measurement	“In our experience, SCF is likely to fail without changes of incentive structures.”, “We introduced working capital targets for direct and indirect materials. These were specified at category level. There are different ways how logistics managers may achieve these targets, but it is clear to date that working capital optimization and thus SCF adoption along the supply base are among the most important ones.”
	Technology	“It was quite tedious to adjust our ERP system to fit to the SCF platform offered by the [bank]. In total it took probably half a year.”, “We developed a new payment platform internally, anyway. When we learned about SCF, we discussed with our bank how we could adjust our systems to become fully compatible. That was actually not too complex.”, “Moreover, we had to develop software internally and adjust our systems. [...] but in total, these efforts where not significant.”
Supplier involvement	Suppliers’ opinions included in decision making	“We started recently two pilot projects in two European countries.”, “We first thought, SMEs would be primarily interested in participating [...], but interestingly we were wrong—that surprised us. In contrast, another supplier—a large firm—was much more eager to join the system, particularly due to off-balance sheet effects.”, “We used the experience gained in these pilot countries to improve our SCF solution to fit to a broader population of suppliers.”
	Feedback taken seriously	“The feedback from suppliers helped us to focus on such benefits and to better address suppliers’ needs.”
	Timeliness	“As soon as we recognized the importance of suppliers in the process, we tried to include them in pilot studies. The feedback of these selected firms was used to push the project forward.”
Dissemination	Suppliers become aware	“In most European countries, suppliers have not heard of SCF. So we had to explain it to them.”, “As soon as the first manager of a supplier says ‘sounds great, we are interested,’ we have a first success.”
	Suppliers become persuaded	“We really need to go there and persuade suppliers that were not involved at an early stage of the project. We have workshops with their CFOs and explain the concept in-depth to persuade them based on the benefits both parties can obtain”, “Sometimes we use our market power to ‘persuade’ suppliers.”
	Suppliers adopt SCF	“Well, you know it is finally great to see that you are successful with the project and suppliers adopt it. Recently, two or three really important suppliers in terms of spend volume agreed to use SCF.”

Continued.

Table 3: (Continued)

Category	Codes	Original quotes
Relationship strength	Trust	“Instead of us also the bank could approach our suppliers initially. However, suppliers don’t trust banks like they trust us. Due to long collaboration, these suppliers know us and once we explain the idea, they say, ‘okay, we are interested in the benefits.’ ”
	Power	“If we have more power and if we perceive that SCF is beneficial for both parties, we expect our suppliers to extend payment terms but offer them SCF in advance, to ensure they have cheap access to short-term liquidity.”, “When we are talking with smaller suppliers, where we account for 30–50% of their sales, we simply tell them to use SCF.”
	Communication intensity	“We work very closely with our colleagues from finance when we conduct workshops with suppliers. Our finance colleagues are very important to assure our credibility in these workshops. They are our experts regarding financial and accounting issues and the suppliers participating in such workshops usually bring their CFO to the table.”, “With smaller suppliers, we usually use written communication or a procurement manager negotiates with them one-on-one. [...] ‘We will extend payment terms anyway. It is up to you—take our SCF offer or leave it.’ ”
SCF leverage	Credit rating	“For sure, our strong credit rating was required. Without it, we could have never offered such good conditions to our suppliers.”, “In all ratings we are graded very well, so we bring a strong cost reduction argument to the table.”
	Bank integration	“Our bank trusts us. We work together with them since more than 100 years and they know our records and how we conduct business.”, “Well, actually we are very grateful to our bank, because due to its experience and our close collaboration, the bank was able to assist us with many legal issues.”, “The experience with our bank is extraordinary: The collaboration was excellent, they are very experienced. They have very good procedures and are very committed to the system as such and our collaboration in general.”
	Qualitative benefits	“One is quick with overlooking benefits that cannot be measured in numbers. For instance, the pure availability of a new source of funding might be more important for some treasurers of our suppliers than whether they save some money.”, “The SCF solution is very well integrated in our system and thus offers many benefits to us as well as the suppliers. The payment process got even easier and our suppliers appreciate having more flexibility and information.”, “One of our suppliers told us, that he estimates to save two man-days, as the reconciliation is much easier for him. He has quite some benefits even if he does not use the credit, because he always knows immediately when his invoice has been released.”

et al. 2009), we find a strong overlap with existing knowledge on focal firm adoption decisions. Yet, there is no interaction with the supply base prior to the implementation stage.

However, there are some unique features inherent to SCF as an upstream innovation. On the one hand, buying firms as innovators play a stronger role than sellers of innovative products in identifying SCF as possible solution. Whereas in downstream cases demand for innovation is signaled by customers or competitors often more explicitly, in the case of SCF the sample firms reported that few suppliers asked explicitly for a SCF solution because other firms they supply also offer it to them. So, the origin of this innovation lies in the buying firm itself and, hence, SCF could be considered a push rather than a pull innovation. Moreover, SCF requires firms to consider working capital efficiency gains through structural adaptations. So, instead of attaining immediate success through innovative products like in the case of downstream product innovations which pass through a lifecycle linked to their profitability, SCF is initiated in firms with a long-term focus on recurring efficiency improvements.

Implementation of SCF

The effectiveness of innovation adoption depends on the fit between the organization and the innovation itself (Van de Ven 1986). This fit can be achieved in three ways: by restructuring the organization, by redesigning the innovation, or a mixture of both (Rogers 2003). We will now describe our observations with respect to redefining and restructuring, analyze common patterns among all cases, and propose three generalizations. For summaries of codes and original quotes, please refer to Table 3.

Redefining

Redefining SCF is a process during which firms not only adjust the SCF innovation to their specific context but also initiate a process in which firms need to reconsider the contextual factors to which the SCF innovation needs to fit (Johns 2006). The valuation of these factors varies over time, as we learn. Epsilon’s financial manager claimed: “Although the economic idea is the same in different SCF solutions we considered, they all differ in details. [...] In the beginning, our priority was to find a solution

that best fits our needs.” We learn that the value added for suppliers gains increasing importance during the adoption process. Epsilon’s procurement manager argues as follows: If SCF serves only Epsilon’s needs, but not the supplier needs, why should any supplier agree to use SCF? So, Epsilon analyzed how SCF can be configured to fit supplier needs. One aspect of this adjustment is the particular focus on the provision of visibility into cash flows and invoice releases such that the suppliers of Epsilon obtain the maximum degree of flexibility, as they can better plan when they will receive cash flows. Similarly, Delta and Zeta found solutions to particularly serve supplier needs. Another aspect of the redesigning of the innovation is revealed by Delta as it builds its SCF implementation on an already existing automated payment platform within its corporate group. From a technical and information system perspective, Delta thus only needed to adjust this platform, rather than to integrate an entirely new one. In this way, Delta redesigned the SCF innovation to its own needs, rather than having implemented an external standard solution. Thus, firms go through a process of defining criteria to which the SCF innovation needs to fit, before they can actually redefine SCF.

A pattern that emerged among all cases is that there are three broad categories of redefining SCF which firms need to consider to make context fitting decisions: (1) benefits allocation mechanisms, (2) degree of automation of transactions, and (3) scope of suppliers using SCF, summarized in Figure 3.

Restructuring

The SCF innovation requires cross-functional collaboration of finance and logistics as well as procurement in a way which was new to all our sample firms. This becomes evident from Epsilon’s financial manager who stated: “As I never had any operational contact to suppliers I first had to get to know our internal managers for suppliers.” To not know the own colleagues from the upstream supply chain functions indicates the absolute absence of any form of direct communication, making direct collaboration infeasible (Grant 1996; Kahn and McDonough 1997). But, active collaboration between finance as well as logistics and procurement managers is required to adopt SCF successfully because the former are dedicated financial experts and the latter often manage the interface with suppliers (Stefansson and Russell 2008). So, the first step was to bring together responsible managers of each function in the case of Epsilon. From initial occasional project meetings, quite formalized patterns of collaboration emerged. At Epsilon, we observed weekly formalized meetings to discuss recent issues, but also informal meetings whenever necessary indicating cross-functional collaboration (Pinto et al. 1993; Kahn and McDonough 1997).

Moreover, adjustments with respect to job design had to be made. Particularly in firm Zeta, conflicts arose due to new tasks inherent to SCF, as its finance manager explained: “Procurement managers initially said, it is not our task to use SCF, it is not in our working contracts and job description. We do not want to implement SCF.” In contrast to traditional tasks of upstream logistics and procurement managers (Chopra and Meindl 2012), the adoption of SCF requires further tasks as it becomes necessary to market the SCF innovation upstream. These marketing skills, however, are quite distinct from traditional skills present in these functions (Ellinger et al. 2000). Typically, in the case of

downstream innovations, marketing and sales people are much more experienced and proficient in promoting innovations to their customers than logistics and procurement managers having to market upstream innovations to their suppliers. This adds further complexity to their job which has to be accepted and learned by procurement and logistics managers first. Therefore, this demand for capability building during the adoption process contributes further to the widely adopted quest for a more strategic mind-set and strategic skill-sets in upstream supply chain functions (Das and Narasimhan 2000).

Furthermore, restructuring includes alignment of performance measurement systems and incentives of individual managers, as we observe at Epsilon whose financial manager explained: “In our experience, SCF is likely to fail without changes of incentive structures.” In line with previous research this can likely be generalized (Eisenhardt 1989a; Prendergast 1999). Interestingly, our observations show the particular need of aligning logistics and finance incentives with respect to working capital.¹

Our analysis shows further how restructuring and redefining are interrelated. On the one hand, decisions on the three categories of redefining, which we identified above, can only effectively be made as the buying firm succeeds in restructuring. On the other hand, the organization needs specifications derived from the redefinition process to effectively restructure any of these categories. Therefore, both processes are truly intertwined and involve each other. More formally,

Proposition 1

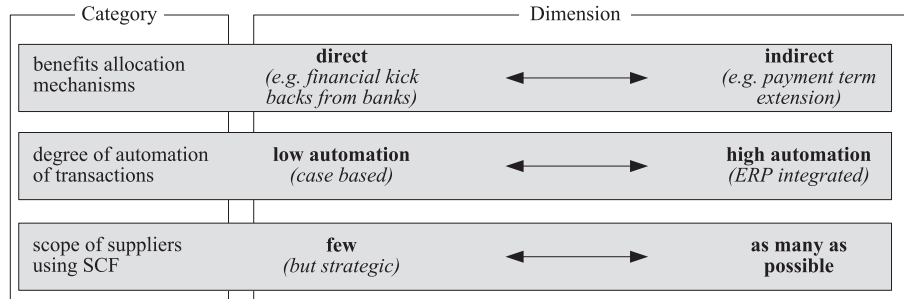
Restructuring of organizations internally and redefining the SCF innovation according to the supply base needs are interrelated and mutually enforcing processes in the sense that neither alone can be successful without the other process advancing.

Effectiveness of restructuring and redefining

The progression of the mutually enforcing processes of restructuring and redefining may assume different levels of effectiveness, as we observed at Gamma, Delta, Epsilon, and Zeta. This suggests that the relationship above might be moderated by another factor. In particular, our analysis reveals two factors.

First, the adjustment of performance measurement and the increased use of cross-functional teams bring redefining and restructuring processes together. Epsilon, for instance, was only able to combine both processes when logistics and financial managers started to work in teams. Likewise, for Zeta the alignment of its finance and strategic procurement function, which was responsible for the SCF implementation, was required. We will refer to both, adjustment of performance measurement and cross-functional collaboration, as logistics/procurement-finance align-

¹Working capital equals inventory and cash plus accounts receivables minus accounts payables (Brealey et al. 2007). Previously, the logistics objective was to focus only on inventory while SCF also requires focusing on accounts payables, if the buying firm decides to use payment term extension as a means of benefit allocation.

Figure 3: Categories of redefining the supply chain finance (SCF) innovation.

ment. With this term, we indicate that up-to all three functions need to be aligned toward common goals of SCF while we acknowledge that whether or not logistics and/or procurement needs to be aligned with the finance function depends on the organizational structure, as Epsilon and Zeta show. Such an alignment differs from the prior working relationship between the three functions in all analyzed firms. Whereas before adopting SCF members of these three functions essentially only agreed that costs have to be reduced (only procurement and logistics have certainly more congruence), logistics/procurement-finance alignment implies that all of these functions share the same objectives and think in the same direction toward SCF aims based on a broader mindset. The involved functions need to agree that a practice such as SCF can actually improve corporate performance, although it is distinct from the traditional tasks of logistics and procurement. On the other hand, financial managers involved in the SCF project need to understand challenges in the current supply chain setting, before deciding on how to use SCF. Yet, logistics/procurement-finance alignment does not per se lead to SCF adoption. Consider for example Delta, which recently gained quite high-internal alignment regarding SCF, but is still in early stages of the implementation process. Nevertheless, logistics/procurement-finance alignment strengthens the link between redefining and restructuring, and thus indirectly has a positive impact on the effectiveness of SCF implementation.

Second, a similar pattern emerged with respect to early involvement of suppliers. Delta, Epsilon, and Zeta have only concentrated on the internal perspective in the very beginning, but soon recognized the need to include the interest of suppliers as well. Therefore, they selected suppliers for pilot projects, conducted intensive workshops, and remained open for serious feedback of suppliers. The objective of such an involvement is to get meaningful feedback on SCF for a defined time during the adoption project to redefine SCF according to the suppliers' needs. This is opposed to the previously studied supplier integration for recurring interaction focusing on the joint set-up of infrastructure for efficiency in recurring NPD projects with preferred suppliers (Monczka and Morgan 1996; Das et al. 2006). A consequence resulting from this difference is manifested in the selection of suppliers for early involvement in the restructuring and redefining stages. In the case of Delta, we learned that important, but not crucial suppliers were selected for these studies, as Delta was afraid of unpleasant side-effects such as endless workshops distracting a supplier's valuable resources from required business. Furthermore, these suppliers were purposefully selected:

Particularly large suppliers with credit ratings lower than the buying firm were preferred, as these have higher potential benefits.

This *involvement of suppliers* had two major outcomes: first, redesigning SCF to match the needs of the supply base became significantly easier. And second, the organizational restructuring got more sophisticated as the discussions with suppliers led also to a closer collaboration and information exchange of finance, logistics, and procurement managers. So just like logistics/procurement-finance alignment, the involvement of suppliers per se does not increase the effectiveness of the SCF implementation directly, but it strengthens the link between restructuring and redefining indirectly. More formally,

Proposition 2

The interrelated progress of restructuring and redefining is moderated (a) by logistics/procurement-finance alignment and (b) by supplier involvement with the progress being more effective with higher levels of logistics/procurement-finance alignment and supplier involvement.

Clarifying and disseminating

We now turn our attention to the time period after firms have successfully accomplished redesigning and restructuring. In particular, we focus on Epsilon and Zeta as they reveal mechanisms that may be generalized to predict which firms are more effective in the adoption process toward reaching the routinizing stage. During this period, firms have two main objectives.

First, firms need to persuade all inbound logistics and procurement managers related to the operational use of SCF. Zeta's financial manager described: "We conducted several workshops with upstream supply chain managers [...], but yet there was much resistance. They needed to see some good examples of their colleagues. Once these colleagues were formally appraised in meetings, everyone began to understand that SCF is important and the acceptance grew." Similarly, his colleagues from upstream supply chain functions shared the opinion that one of the most important aspects was to persuade managers to use SCF. Although in the case of Epsilon resistance was lower, Epsilon's managers still reported to have many meetings to "get everyone on board" (logistics manager). As this process is very similar to what Rogers (2003) calls "clarifying," we will use the same term.

Second, in contrast to existing literature on organizational innovation adoption stating that clarifying is among the most crucial aspects of innovation adoption (Van de Ven 1986), we identify another process of equal importance: *upstream dissemination*. It refers to the concept of accelerating the innovation diffusion among suppliers and ultimately to make them use SCF. While the firm Delta is not yet in this stage and rather plans how to disseminate the innovation among its suppliers, Epsilon and Zeta provide detailed insights on this process step. Both reveal that dissemination would be straight forward, if upstream supply chain managers of the focal firm could directly talk to the people in the selling firm responsible for SCF (often the CFO). But, instead of talking to CFOs, they rather communicate with sales managers who are “often either not competent with respect to financial decisions or simply not interested in it” (procurement manager, Zeta). So, the first task is to create awareness among the suppliers’ decision makers, usually involving financial managers and less frequently sales managers. Once they are aware, they need to be persuaded of the benefits and eventually it has to be ensured that these suppliers actually use SCF. Accomplishing these three steps is considered a success by Epsilon. During this stage, it is “essential to have support from finance” (Epsilon, procurement manager), but also to achieve clarification (i.e., a sufficiently large number of upstream supply chain managers of the buying firm believing that SCF works and wanting to use it). In particular, the latter is important as these managers usually have the direct contact to suppliers.

Thus, a tight relation between clarifying and disseminating seems to exist as both are connected: Without clarification, few upstream supply chain managers will put effort into disseminating the SCF innovation. The dissemination itself and successful on-boarding of suppliers in turn has a positive impact on the clarification as it proves the feasibility and value of SCF. Thus we posit,

Proposition 3

Clarifying and disseminating are interrelated and mutually enforcing processes in the sense that neither alone can be successful without the other process advancing.

This stage of dissemination is distinct from previous research as the role of external members in the innovation process is much smaller in common organizational innovations (Van de Ven 1986; Rogers 2003). Therefore, our analysis required us to go beyond our knowledge about previous innovations and to explore attributes increasing the effectiveness of firms during the dissemination stage. In contrast to previous downstream innovation dissemination, the focus of SCF is more on persuading the right people than on maintaining and improving interorganizational relationships by specific long-term investments to develop new products (Kim 2000). Note, that both tasks are quite distinct.

Effectiveness of the upstream dissemination process

Suppliers are willing to adopt SCF, if they expect high returns, which is central for the assessment of a buying firm’s dissemination effectiveness. Although a buying firm’s credit rating determines in principle the interest rate a supplier would face using

SCF and, thus, ultimately the supplier’s potential savings, we observe that concurrent qualitative benefits might even be more important for suppliers. From Zeta, for instance, we learn that suppliers gained flexibility through online visibility into the payment process and the automatization provided by the SCF solution. Delta also witnessed during its pilot studies that having another source of finance might be more valuable to some suppliers than the mere financing cost difference. All such benefits a buying firm can provide to its suppliers were categorized as *SCF leverage*. These benefits result from the buyer’s credit rating and the configuration of SCF, particularly the allocation of benefits. Therefore, SCF leverage is rather specific to the organization than to the relationships with suppliers. It is important to understand a buying firm’s SCF leverage to predict whether or not it will be able to effectively disseminate the SCF innovation: Thus,

Proposition 4a

SCF leverage has a positive impact on the dissemination of SCF in the sense that it increases the effectiveness of the dissemination process in the supply base.

Furthermore, the individual buyer–supplier relationships as well as the communication channels used play a pivotal role. Particularly important are the two well-known constructs trust and power (Emerson 1962; Casciaro and Piskorski 2005; Thomas and Skinner 2010). The absence of trust reduces the supplier’s willingness to adopt SCF, as we learn from Epsilon that made several attempts, where its bank tried to directly contact suppliers. However, these suppliers expected that there is a catch to SCF, as they did not trust an external bank they are not currently doing business with. But, when Epsilon started to expound the benefits with almost the same explanation, these suppliers became interested. The positive effect of trust can be observed in further cases, thus it is plausible that for all firms trust is an important attribute for innovation dissemination.

Furthermore, the cases Epsilon and Zeta reveal that buyer power is also used for disseminating the innovation upstream. For instance, if Epsilon is in a very powerful position with a certain group of suppliers, it dictates them to use SCF, as Epsilon’s financial manager explained: “We would say to our supplier, ‘We will extend payment terms anyway. It is up to you—take our SCF offer or leave it.’” And none of these suppliers refused to use SCF, because this kind of coercive power does not leave the supplier any real choice (Bacharach and Lawler 1981; Lawler 1992; Benton and Maloni 2005). Similar to trust, power is a relational strength that has emerged from previous interaction between the buying firm and suppliers (Emerson 1962; Pfeffer and Salancik 1978; Casciaro and Piskorski 2005). An interesting aspect of our observations is, however, that even coercive power is used intentionally to bolster suppliers, whereas previous studies showed that coercive power is rather used as a means of supplier exploitation (Benton and Maloni 2005).

Furthermore, Epsilon and Zeta have different tools of persuading suppliers of the SCF innovation, ranging from simple communication, such as standard e-mails and phone calls to more sophisticated communication including meetings and workshops

where financial experts from both parties are involved. In particular, we see the use of the latter rather with suppliers of high importance.

These three attributes—trust, buyer-power, and communication obtrusiveness—reflect categories of *relationship strength*, as each of them is relationship specific opposed to SCF leverage. The more buyer-supplier relationships are characterized by such strengths, the more effectively a buying firm can disseminate SCF in the supply base. More formally,

Proposition 4b

Relational strength has a positive impact on the dissemination of SCF in the sense that it increases the effectiveness of the dissemination process in the supply base.

Propositions 4a and 4b state that buying firms have particularly four concepts for persuading suppliers, namely SCF leverage, trust, power, and communication obtrusiveness. These concepts determine the *enforceability of dissemination* (i.e., the persuasiveness of the buying firm). But they differ clearly in their results: although a concept such as buyer power virtually forces weaker suppliers to adopt SCF, the other extreme of purely offering benefits might be less effective as discussed above. Another important dimension is the long-term buyer-supplier *relationship quality*. In contrast to the enforceability of dissemination, offering true benefits to the supplier has a positive impact on the buyer-supplier relationship quality (Ganesan 1994), while the use of coercive power might deteriorate supplier satisfaction (Benton and Maloni 2005). Between both extreme poles are trust and communication obtrusiveness. Although both are slightly more enforcing than purely suggesting benefits, their overuse may deteriorate the relationship quality as well. As communication becomes too penetrative, suppliers may generate a feeling of resentment.

This trade-off between enforceability of dissemination and the quality of buyer-supplier relationships uncovers a specific dilemma of upstream innovation dissemination. Although SCF usually benefits the supplier, there might be resistance or inertia in the supplier base, which might induce buying firms to employ more effective concepts of persuasion deliberately risking a decrease in buyer-supplier relationship quality. This is different in downstream dissemination where often customers actively demand innovations (Neale and Corkindale 1998; Gruner and Homburg 2000). Therefore, in the downstream dissemination achieving high enforceability and a positive impact on relationships is often not a contradiction opposed to upstream dissemination. The effect of concepts used for accelerating the upstream dissemination process on the enforceability of dissemination and the buyer-supplier relationship quality are characterized by Figure 4.

DISCUSSION OF SPECIFIC FINDINGS ON INNOVATION ADOPTION OF SCF

In the previous analysis we have developed four sets of propositions that characterize the SCF adoption process from a buying firm's perspective. Based on an extension of Rogers'

(2003) framework, it is possible to combine these propositions into a framework of SCF adoption. Opposed to organizational innovations, redefining SCF requires taking needs of the upstream supply chain partners into account. This process is closely interrelated with restructuring organizations (Proposition 1). This interrelation increases the complexity of adopting SCF as opposed to general innovations, in which redefining and restructuring can be decoupled and managed sequentially.

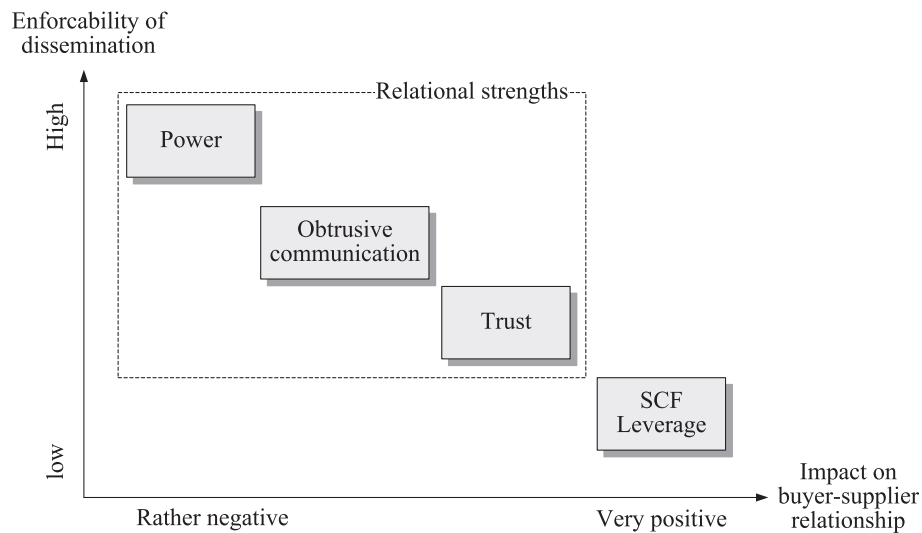
Furthermore, we find that firms will be more effective during this stage, if they achieve logistics/procurement-finance alignment (Proposition 2a), which is an entirely new phenomenon in many organizations. Whereas collaboration between both functions can be witnessed in operational cost reducing projects, the strategic alignment targeting toward a shared objective is new in many firms, as this often requires enhanced mutual understanding and a broadened skill-set of logistics, procurement, and finance managers. This logistics/procurement-finance alignment is also typical for SCF, whereas previous processes may have required internal alignment, the alignment was usually between two operations functions such as manufacturing and procurement (e.g., Narasimhan and Das 2001) or logistics and marketing (e.g., O'Leary-Kelly and Flores 2002) other than an alignment between corporate finance and operational upstream logistics or procurement. The early involvement of selected suppliers in innovation projects is neither entirely new to the buyer nor to these suppliers (Proposition 2b). It is rather the SCF innovation in itself that is a complete novelty to the personnel of the buyer and the seller. This creates management challenges for the buying firm internally and thus also externally when involving selected suppliers at an early stage when the own organization has not yet fully clarified and absorbed SCF.

Next, firms need to clarify internally and disseminate the configured SCF innovation upstream. Both processes are closely intertwined and presuppose each other (Proposition 3). Moreover, the ability of the upstream supply chain functions to compensate for their lack of experience in marketing chances and benefits of the SCF innovation to an outside entity differentiates effective SCF adopters from less effective firms. In design chain management with suppliers for effective NPD, the benefits are explicit and obvious to the suppliers given the relational history of collaboration in this domain. Again, this intertwinement increases the complexity of the adoption process. Although particularly finance managers often lack the focus on suppliers' needs, it is the responsibility of the logistics and/or procurement function to ensure that enough suppliers are on-boarded.

Moreover, the dissemination of SCF can only be accomplished if the redesign was successful and if firms have SCF leverage (Proposition 4a) and relational strength (Proposition 4b). Opposed to downstream dissemination, firms have to consider the trade-off between dissemination enforcement and long-term relationships. Figure 5 illustrates the extension of the Rogers (2003) framework and shows how our propositions add to the understanding of the SCF adoption process.

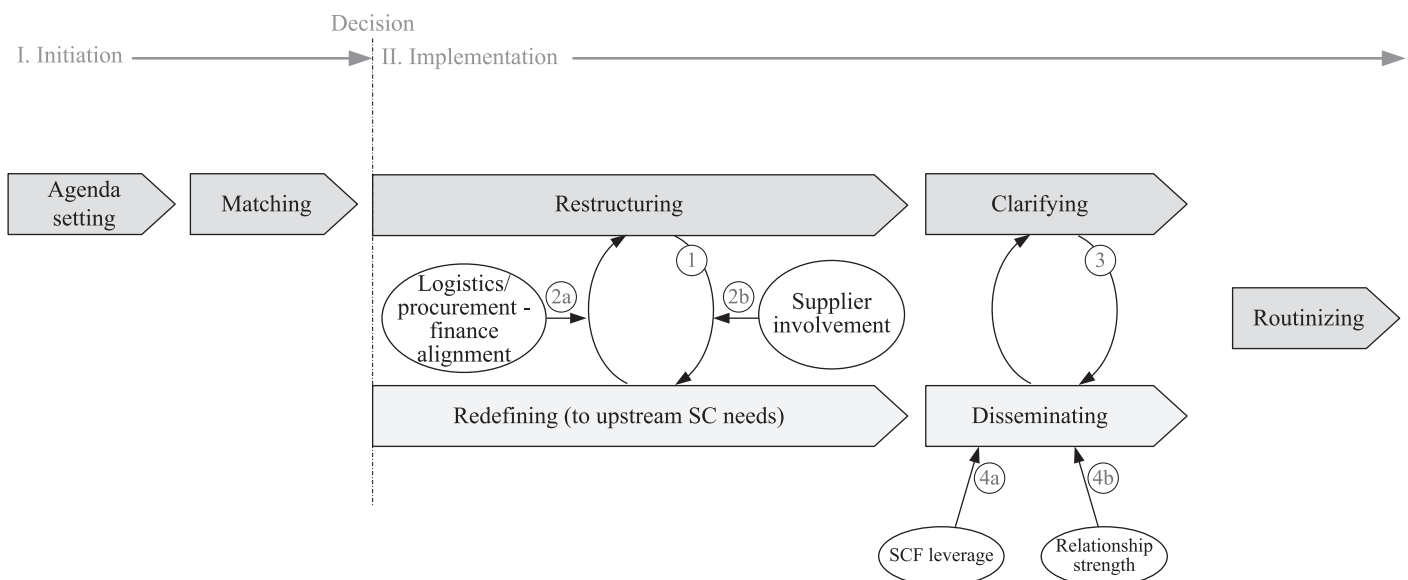
CONTRIBUTION, INSIGHTS, AND LIMITATIONS

The theoretical contributions of our research to innovations in logistics are manifold. First, we add to the emerging research

Figure 4: Enforceability and relationship impact of dissemination concepts of supply chain finance (SCF).

on the logistics and finance interface (e.g., Buzacott and Zhang 2004; Berling and Rosling 2005; Caldentey and Chen 2009; Hofmann and Kotzab 2010) by taking an organizational perspective. Whereas previous research in this new domain focused mainly on the outcomes of managing the financial and physical flows jointly, we explore the process of getting there. We contribute by positing testable propositions relating detected internal and external management practices and buying firm characteristics to the progress of the SCF adoption process. Moreover, we add to previous conceptual insights on SCF. Opposed to previous research in this domain being rather conceptual, we provide positivistic, empirical results which offer actual real and in-depth insights on what is practiced. While Pfohl and Gomm (2009) show how optimizing financial flows

in supply chains can lead to working capital improvements in general, we analyze a specific approach. By taking this specific approach, we are able to identify several variables that inform the adoption of SCF as depicted in Figure 5, as well as specific means that buying firms may use to disseminate the innovation upstream as shown in Figure 4. Although our research departed from the specific SCF practice, we believe that certain results on the upstream diffusion are transferable to other mechanisms of improving financial flows along supply chains; for instance, those involving logistics service providers as studied by Hofmann (2009) and suggested by Gomm (2010). In the same manner, we also add to the work by Hofmann and Kotzab (2010), who show how firms should collaborate along supply chains to improve working capital. Specifically, this contribu-

Figure 5: Extension of Rogers' (2003) framework.

tion of ours is obtained by studying SCF as a practice which involves a bank to optimize working capital and reduce costs of capital along the supply chain.

Second, we analyze the construct of *upstream dissemination*. This construct takes a central role in the adoption process of upstream supply chain innovations. Similar to the five stages that Rogers (2003) discusses with respect to organizational innovations, upstream dissemination appears to be a further stage, for the adoption and successful routinizing of SCF processes. Without sufficiently many suppliers also adopting SCF, there will never be a state of routinizing. Moreover, this construct is specific as other types of innovations are usually marketed downstream the chain to be adopted by customers and to differentiate the focal firm offerings from competitive product-service bundles (e.g., Cooper and Kleinschmidt 1995). Nevertheless, we believe that this construct can be further generalized to other types of upstream supply chain innovations. It may also provide an explanation why certain firms are more innovative in logistical processes.

Third, although we study the particular process of SCF, we believe that many insights gained here are generalizable to further adoptions of innovative processes focusing upstream the supply chain. In particular, the role of early supplier involvement, internal alignment of previously less integrated functions (e.g., logistics and finance), and relational strengths, as these are not SCF-inherent. Therefore, this study is not only a “how-to-adopt-SCF-study,” but rather a study that provides a broader perspective on upstream supply chain innovations. Against the rising importance of logistics and its impact on organizational performance it is plausible that buying firms will invent further processes which revolutionize aspects of their upstream supply chain not limited to the financial flows investigated in this research. During these processes, we believe, structural insights from our study may serve as a first starting point to systematically analyze the implications when seeking to implement innovations to improve logistical flows between upstream supply chain partners.

Moreover, our research has several implications for logistics managers. We departed from the problem that firms require means to extend payment terms and to provide liquidity for their suppliers at the same time. SCF is an innovative practice which could solve this dilemma. Our findings suggest that (1) Opposed to previous supply chain innovations where financial managers play a subordinate role, SCF requires logistics managers to work closely with their financial counterparts and to understand the mechanism of SCF to persuade suppliers, rather than merely to apply SCF. (2) Opposed to traditional innovations designed to serve customers, SCF requires buying firms to redesign SCF to capture and address supplier demands as if they were customer demands in NPD projects. Therefore, logistics managers need to acquire certain marketing skills and involve suppliers early on to foster later upstream dissemination among a wider base. (3) Managers should bear in mind that SCF will not work for each buying firm. Firms need SCF leverage and relational strength to become effective adopters. Otherwise buying firms can adopt SCF, but will face only a little proportion of suppliers using it. (4) If a buying firm eventually decides to adopt SCF, it has different concepts at its disposal for the upstream dissemination. When choosing the approach, managers need to take the trade-

off between enforceability and impact on buyer-supplier relationship into account.

However, as with all empirical research our study also has several limitations. As we limited our study to the specific implementation of SCF, it would be interesting to see if the propositions also hold in different settings. For instance, as besides financial institutions such as banks also logistics service providers may engage in cash flow optimization (e.g., Hofmann 2009), it would be interesting to hypothesize that the same attributes of buying firms are required for upstream dissemination as in the case of SCF and to test whether this holds. Since our primary objective was to understand the SCF adoption itself, we explored this process in six firms. Although we selected cases deliberately, it is not possible to conclude that the findings are transferable to all firms without adjustments. However, having derived testable propositions, future research might test them in large-scale studies in related domains. A further limitation is the restriction to European firms. It is plausible to assume that distinct banking and industrial contexts would significantly alter the adoption process (e.g., limited use of electronic banking and strong use of checks in India). But, particularly in regions where suppliers' access to financial markets is more restricted, they might be demanding innovations such as SCF even stronger than European suppliers do. Finally, our study captures a snap-shot of the adoption process in each firm. It would be interesting to study firms longitudinally as this would show if each firm follows the innovation adoption process detected in this research.

Our study also reveals further adjacent research topics which might guide researchers interested in the domain of SCF. First, it would be interesting to broaden the research on upstream innovations to more than one type of innovation. This would foster the understanding of the particularities of upstream innovations and help to differentiate between internally and externally oriented firm practices and characteristics that are specific for the success of the SCF adoption and those generalizable to other types of upstream innovations. Second, it will be interesting to analyze the SCF innovation from the viewpoint of the supplier to further complement our understanding of upstream innovations. This approach might also reveal further success factors for the implementation of SCF.

Even though our study is not without limitations, we believe that our study marks a first cornerstone in the exploration of this important and fast evolving field of the coordination of interrelated finance and logistics decisions.

ACKNOWLEDGMENTS

An earlier version of this article was presented at the CSCMP European Research Seminar (ERS) in Frankfurt in May 2012. We wish to thank the attendees for sharing insights that helped improve the quality of the article. We also want to thank the participants of a research colloquium held at EBS University for their comments and thoughts which helped to strengthen our manuscript. Moreover, we are thankful to the three anonymous reviewers for their insightful and constructive feedback. Finally, our thanks go to the Studienstiftung des deutschen Volkes, which supported David Wuttke with a scholarship during this research.

APPENDIX CASE DESCRIPTION

COMPANY ALPHA

Alpha is a multinational coating and chemical company. Although it supplies both, industry and consumers, we focus on its industrial coatings sector. Alpha has a very strong reputation for sustainable business practices requiring innovation. The financial crisis heavily affected the specialty chemical as well as the coatings industry. Supplier defaults as a consequence of liquidity shortages were, however, rather the exception.

Despite being innovative in products, Alpha is still in a very early stage of the SCF adoption. Alpha's managers were only becoming aware of SCF and its benefit. Alpha still hesitates to implement SCF as many suppliers are from Northern Europe, particularly the United Kingdom where payment terms are relatively short. Therefore, these managers believe that potential benefits of SCF might be rather small. On the other hand, Alpha's managers are concerned about "bringing the innovation through the supply chain," as other matters are of higher importance for its suppliers than financing like sustainability projects. Therefore, Alpha's managers are afraid that enforcing SCF too heavily in the supply base might have negative consequences.

Thus, Alpha can be considered being in the matching stage as it tries to identify how SCF could help to meet its logistics goals of further inventory optimization along its supply chain.

COMPANY BETA

Beta is a globally leading aircraft manufacturer. The aviation industry is characterized by high levels of safety standards making it almost impossible to exchange strategic suppliers. A further characteristic of this industry is that many products are prefinanced by the buyer including advance payments. Thus demanding payment terms extensions for strategic suppliers is rather unusual for Beta. At the moment, Beta is trying to improve its working capital through consignment stock and vendor managed inventory (VMI), as, during the financial crisis working capital gained increasing importance. Therefore, the reduction of working capital, also with a strong cash focus, is on the top of Beta's corporate agenda.

Beta's managers, at the time of data collection, have been gathering information from diverse banks to understand how SCF could fit to its particular supply chain and industry setting. However, against the background of high safety standards, Beta's managers appear also quite risk-averse when it comes to implementing process innovations such as SCF. Therefore, Beta managers believed that it was better to wait for other firms adopting SCF to avoid early adopter risks. Moreover, Beta believes that it will depend more and more on financially healthy suppliers in the future. Thus, its suppliers should rather be able to finance themselves than relying on solutions like SCF. Finally, there is a lack of top-management commitment regarding SCF, as other working-capital related projects such as VMI have been recently launched.

Hence, Beta can be considered in the matching phase, but is potentially rejecting SCF.

COMPANY GAMMA

Gamma is in the chemical industry supplying mainly industrial firms. During the financial crisis it suffered heavily from industry downturn. Although supplier defaults were exceptions, Gamma's managers perceive that many of its suppliers have financial constraints and might be negatively affected by extended payment terms of Gamma.

Gamma has recently launched several initiatives targeting the improvement of working capital. Thereby, it approaches the cash conversion cycle holistically: After significant reduction of inventories, it strived for the systematic extension of payment terms with its suppliers, and reduction of payment terms with its customers. Whereas these measures allowed substantial working capital improvement, management is now concerned that further improvements are difficult. Therefore, top managers of Gamma are continuously urged to identify new means of improving net working capital.

In 2009, Gamma first got exposed to SCF, as it learned from successful business cases in other industries, mainly the automotive industry. Due to its centralized cash management team, SCF obtained quite fast top management commitment. Within the corporate team, Gamma identified soon how SCF could potentially be matched with its own needs and how it could be employed. However, the team also faced immense challenges implementing it. For instance, financial auditors mentioned that SCF might result in classification conflicts in auditing, as under certain circumstances amounts handled through SCF could no longer be classified as accounts payables, thus destroying the working capital effects of SCF. Furthermore, Gamma has a relatively weak credit rating in comparison to other firms in our sample, which might be still better than some of its suppliers, but managers perceive a lower benefit due to the credit rating.

As Gamma found no satisfying solution it still tries to restructure SCF according to its own needs.

COMPANY DELTA

Delta is an innovative company in the pharmaceutical industry. In this industry, margins for patented products are quite high even during the financial crisis. Particularities of the industry are the extremely high requirements on product availability because production stops might threaten lives. Therefore, Delta's highest supply chain objective is a stable supply of raw materials. Working capital optimization and payment terms are rather secondary targets. However, during the financial crisis certain suppliers faced immense financial shortages. As one manager of Delta states, "the question was no longer whether suppliers were able to deliver the right quality at the right time, but rather whether they would be financially able to deliver at all." Therefore, increasing attention was placed on working capital management, particularly with respect to suppliers.

Independent from its supply chain, Delta started a payment centralization project in close collaboration with its corporate bank in 2009. The aim of this project was to increase transparency of its payment processes and to pool cash resources on a company-wide scale. This project required substantial changes in its internal platforms, as Delta is a huge, global firm with dispersed subsidiaries.

So, two important developments came together, when Delta first learned about SCF: On the one hand, the need to increase liquidity in its upstream supply chain and on the other hand, the availability of an integrated payment platform was desired. While arguably Delta would have the financial resources to always pay immediately, it is still reluctant to do so, as this would cause Delta's working capital to deteriorate significantly. But, SCF was recognized as promising solution, because it improves the liquidity situation of Delta's supply chain without deteriorating its own. Moreover, the expenses appear to be small, as the new payment system is so flexible, that it can easily be adjusted to SCF.

During the most recent interviews we learnt that Delta is currently engaged in conducting two pilot SCF-studies with two important, but not overly strategic suppliers to better learn under which circumstances SCF fits best and how it should be configured in Delta's particular case. Although Delta's industry situation is quite distinct from other firms we studied, the challenges it faces are similar to others. Delta needs to convince its suppliers as these are not per se interested in SCF and in bringing in a new bank corporate bank to do business with.

Therefore, Delta could be considered to be in the implementation stage. Particularly, its most recent objective during the time of data collection was to redesign SCF according to its supply chain needs through the involvement of selected suppliers.

COMPANY EPSILON

Epsilon is a global leader in the raw materials and chemical industry. Innovations in general and continuous introduction of innovative products are key cornerstones of its business strategy. As such, Epsilon is among the innovation leaders in its industry. While Epsilon witnesses the increasing need for sustainability along the supply chain, it tries strongly to incorporate financial sustainability. Moreover, Epsilon has many suppliers in Central and Southern Europe, where payment terms are typically longer than in Western Europe. Therefore, Epsilon perceives a comparatively higher need to manage financial flows along its supply chain. Overall, Epsilon faced very high levels of working capital, which Epsilon wanted to decrease as quickly and sustainable as possible.

When it first got exposed to the idea of SCF in 2008, Epsilon's managers quickly sensed the great potential of this solution. Epsilon set up a task force team composed of procurement and finance managers to identify potential SCF solutions offered by diverse international banks. But, Epsilon also encountered difficulties from its financial auditors, as these demanded to classify amounts covered by SCF as liabilities against financial institutions. However, Epsilon was able to identify certain rules together with its financial auditors, under which these amounts remained classified as trade credits.

During interviews conducted with managers from Epsilon, we learned that suppliers are still actively on-boarded onto the SCF platform. To achieve this, Epsilon uses different means. For high-procurement volume suppliers, workshops with the suppliers' sales and financial managers are carried out. In case of small, less important suppliers Epsilon's procurement managers inform them during negotiations about the SCF solution. Typically they would approach their suppliers by simply demanding

extended payment terms, but offering SCF as a means of reducing the resulting burden to the supplier.

Epsilon is content with the already achieved results of the SCF solution. Therefore, the plan of Epsilon is to bring SCF into a routinizing state now, to use it in its daily processes, where on-boarding new suppliers will rather be an occasional exception.

COMPANY ZETA

Zeta is a German manufacturing company in the automotive industry facing a highly competitive environment with enormous pressure on costs and working capital. The pressure on costs even increased during the financial crisis, when customer demand was significantly smaller and capacities could not be fully utilized. Zeta is known for innovative and high quality products.

Zeta, although it produces in Europe where it faces rather short payment terms with its suppliers, delivers to Asian firms which usually have long payment terms. Therefore, on average it pays its suppliers 20 days earlier than it is paid by its customers. However, Zeta achieved a level of payment term extensions with its suppliers where it would be difficult to further extend the terms without facing serious liquidity problems of suppliers. So even before the financial crisis, already in 2006, working capital management received increasing attention. At that time, Zeta identified the practice called SCF to be successful outside of Europe, but yet did not find any solution provider in Germany. Therefore, it started collaborating with its corporate bank, which so far had no experience with SCF in Germany, to set up a new SCF platform. This project was initiated in early 2007 and shaped by mutual learning between Zeta and its bank.

Early implementation stages were characterized by numerous internal discussions and several struggles caused by a low willingness to adopt a new process. However, when top management commitment raised, communication improved and first positive cases highlighted the acceptance grew. Since the two-first pilots in the end of 2007, an increasing number of suppliers switched to SCF. After a successful adoption of SCF in Germany, further European countries were targeted and suppliers on-boarded. By the end of 2011 almost all important suppliers, which were intended to be switched, have been addressed and invited to use SCF. Many of them agreed.

So, eventually SCF is becoming a routine for the procurement managers. When asked about SCF in 2011, one procurement manager answered us: "SCF is a standard tool, which we use to avoid negative consequences of extended payment terms for our suppliers." This clearly highlights that after Zeta's long way of redesigning its processes and redefining the characteristics of the SCF platform, today SCF is a routine process.

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Where Do We Go From Here? Progressing Sustainability Implementation Efforts Across Supply Chains

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The findings from an inductive study conducted in the United States and Europe focused on sustainability implementation efforts across supply chains are reported. In particular, the study focuses on developing a better understanding of: “how do companies involve other members of their supply chain into their sustainability efforts?” Building upon themes that emerged from the data, a typology for the supply chain implementation of sustainability initiatives is proposed. A lack of supply chain integration was identified and companies reported a tendency toward a “mandated” implementation when extending efforts across companies. These efforts are generally initiated by the dominant companies and then forced onto the weaker upstream members. The data suggests that the merits of these initiatives are viewed as being disproportionately awarded to the dominant firm and thus did not receive full buy-in from the other party. A common vision by both sides of this relationship is to develop a more collaborative implementation that can be supported by all the involved parties. In theoretical implications, empirical findings are viewed through the lens of several prominent management theories in order to augment and elaborate current theory. Managerial implications, limitations, and opportunities for further research are detailed.

Keywords: sustainability; supply chain integration; collaboration

We were in a meeting with a retailer 2 years ago. They said: ‘You WILL [emphasis added] provide us with a sustainable product’. We won’t forget. It wasn’t a question; it wasn’t a request; it was a statement. (Interview # 17, Home Appliances, U.S.)

INTRODUCTION

Today’s consumers pay attention to the environmental impacts of the products they use. Although this awareness might not translate directly into buying behavior—83% of consumers in a recent poll expected companies to become more environmentally friendly, whereas only 22% were going to pay more for environmentally sustainable products (The Nielsen Company 2011)—as such, sustainability claims surely impact the perception consumers have of products, for the better or worse (Luchs et al. 2010). Consequently, an increase in interest in the topic from an industry perspective has been observed (Markley and Davis 2007) and the topic is considered a megatrend in today’s global economy worthy of additional academic focus (Lubin and Esty 2010; Carter and Easton 2011; Fawcett et al. 2011). Despite this rising level of attention, sustainability is often treated as an abstract, relative concept (Faber et al. 2005)—the diversity of business strategies, marketing campaigns, product introductions, and whole corporations labeled “sustainable” adds to the fuzziness around the concept.

There has been only a limited amount of research focused on developing and expanding theory in the area of sustainability as

the term was first defined by the Brundtland Commission as “meeting the needs of the present without compromising the ability of future generations to meet their own needs” (WCED 1987, 8). This perspective toward sustainability is still prevalent in academia, industry, and public media even though alterations (e.g., Solow 1993) and new definitions (e.g., Ehrenfeld 2008) have emerged (Laws et al. 2004). For this study, the term sustainability describes all activities aimed at improving the social and ecological performance of a company while also retaining the financial bottom line (Carter and Rogers 2008; Baumgartner and Ebner 2010). This view toward sustainability is based on the concept of the “triple bottom line” (TBL), which includes economic, social, and ecological perspectives (Elkington 1998).

There have been several attempts to translate the concept of sustainability into business strategy, often referred to as corporate sustainability (Robert et al. 2002; Baumgartner and Ebner 2010). However, implementation in practice still lacks a comprehensive structure and supply chain perspective (Baumgartner and Ebner 2010; Lubin and Esty 2010; Connelly et al. 2011b). This lack of structure is a central reason why even sincere attempts to implement sustainability often result in superficial solutions that deliver insignificantly improved ecological performance, sometimes referred to as “greenwashing” (Laufer 2003; Ramus and Montiel 2005). Although “greenwashing” implies intentionally deceiving consumers about the ecological performance of a product by making it appear “greener” than it actually is, one might extend this perspective to a sustainability initiative that overstates positive results due to a lack of true supply chain integration and clear structure for ensuring cross-firm alignment—despite a firm’s good intentions.

Therefore, the underlying research question of this study is to better understand “how companies involve other members of their supply chain into their sustainability efforts?” Although existing work and theories provide insights into the implementation within

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the four walls of an individual company and the formation of relationships in a supply chain, only a limited amount of research has focused on the interplay between companies as it relates specifically to sustainability efforts.

In the next section, the extant literature is presented and then offered as motivation for addressing the issue of how to implement sustainability efforts from a supply chain perspective. Following this, the methodological process used in this research is described. Next, the findings of the analysis are presented, accompanied by relevant excerpts from the qualitative data, which reflect emerging concepts. This section establishes a typology for implementing sustainability initiatives across one's supply chain and makes propositions for further inquiry. This is followed by a presentation of the theoretical and managerial implications of the findings from the study, along with limitations and future research opportunities. Finally, conclusions are drawn.

LITERATURE REVIEW

While the concept of sustainability has been around for decades, a clearer understanding of the topic has only emerged in the past 20 years (Haugh and Talwar 2010). As sustainability has been discussed in several publications in recent years, the point of this research was to focus on the implementation of the concept across the network of companies that represent a supply chain and expand existing theory surrounding this specific issue as theoretical gaps can be identified in this context (Carter and Rogers 2008).

Green supply chain management

There are several streams of literature that cover the role of sustainability in supply chain management (SCM). One of the major areas is the field generally termed green SCM (GSCM). As the term suggests, the focus here is on the environmental aspects of supply chains. The literature reviews by Srivastava (2007) and Abukhader and Jönson (2004) provide a good overview of this stream of research. Both articles point out that GSCM is mainly derived from a reverse logistics angle, but also has inputs from concepts focusing on overall process efficiency. Reverse logistics describes the upstream flow of resources in combination with a reduction in materials to make the transport more efficient (Carter and Ellram 1998). Reverse logistics activities play an important role with respect to the environmental impact of supply chains and have received amplified attention in the literature. For a current review of work in this area, see Chan et al. (2010).

Srivastava (2007) examines the synergy of the ecological and economic aspects of SCM. This notion has been promoted by several authors before when describing the role of "green" for competitive advantage (e.g., Porter and Van der Linde 1995a,b; Florida 1996; Rao and Holt 2005; Kersten et al. 2010; Mollenkopf et al. 2010). This literature suggests that resource efficiency leads to a reduction in operating costs as well as having a positive environmental impact and thus strengthens the competitive position of the enterprise. However, as Mollenkopf et al. (2010) and Kersten et al. (2010) among others caution, creating genuine and long-lasting competitive advantage for the entire

supply chain also requires a stable and fair distribution of the burdens and benefits across the companies involved.

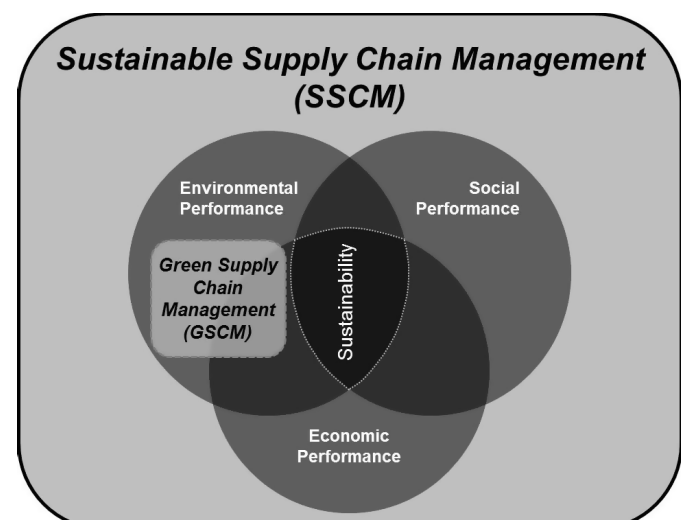
Sustainable supply chain management

The literature analysis by Seuring and Müller (2008b) broadens the view from GSCM to also including the social dimension and thus—drawing on the TBL approach—provides an overview of the sustainable SCM (SSCM) literature. SSCM is defined "as the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key inter-organizational business processes for improving the long-term economic performance of the individual company and its supply chains" (Carter and Rogers 2008, 368). Furthermore, Carter and Rogers (2008) assert SSCM that lacks a theoretical background and suggest a framework for sustainable supply chains that supports the concept of intercompany integration in pursuit of sustainability.

Analogous to the asserted synergy between the ecological and economic bottom line, among SCM researchers, there is a general consensus that companies can create competitive advantage through sustainability-focused activities (e.g., Hart 1995; Bekefi and Epstein 2008; Flint and Golobic 2009; Godfrey et al. 2009; Hart and Dowell 2011). The natural resource-based view of the firm as introduced by Hart (1995) suggests a decisive effect on competitive positioning for sustainability issues (Carter and Easton 2011). Although the positive impact of sustainability on the competitive position is well documented theoretically and anecdotally for individual companies, current literature lacks insights into how the notion of sustainability can be implemented—especially with regard to intercompany initiatives (Wolf 2011).

To shed light on this aspect, a further clarification of the understanding of sustainability and SSCM is needed. As stated previously, the TBL is the main theoretical underpinning for sustainability in this study. The TBL concept was further adapted by Carter and Rogers (2008), as part of their framework for SSCM. The notion of interorganizationality and the fact that even though all three bottom lines are mentioned, ultimately long-term economic performance is the firm's goal, are the main

Figure 1: Illustration of sustainable supply chain management.



ideas influencing this paper. As illustrated in Figure 1, SSCM encompasses the full TBL approach with respect to supply chain operations and strategy as defined by Carter and Rogers (2008), whereas GSCM incorporates only the environmental and economic issues and is thus only an aspect of SSCM.

To implement SSCM, sustainability initiatives should be integrated across selected key members of a supply chain. Several contributions in the literature provide insights into this notion: Rao and Holt (2005) argue—drawing on empirical data—that purchasing as well as operations and distribution activities have to be redesigned with respect to sustainability to create genuine competitive advantage for the supply chain. As purchasing and distribution directly involve suppliers, logistic service providers (LSPs), and customers, supply chain integration in the pursuit of sustainability is an imperative. Similarly, Handfield et al. (2005) assert that sustainability initiatives need to take a strategic supply chain-oriented approach to engrain sustainability in the business strategy of all supply chain members. Darnall et al. (2008) support this notion and show that supply chain integration can be facilitated by the adoption of an environmental management system (EMS). They argue that successful internal implementation of a sustainability effort is a prerequisite for reaching out into the supply chain. While an EMS is only directly relevant for environmental sustainability, initiatives can be rolled out—once in place—to include social issues.

In addition, the literature suggests the need for enhanced cooperation for sustainability in the supply chain (Seuring and Müller 2008a; Hopkins 2009; Pagell et al. 2010; Wolf and Seuring 2010; Seuring 2011), yet most work dealing with sustainability strategies focuses on collaboration only in the economic dimension of sustainability (e.g., Baumgartner and Ebner 2010) and neglects possible benefits of collaboration on the social and environmental aspects. The majority of reviewed publications conclude that the state of SSCM implementation in practice can still be considered low. Although many companies pursue isolated, internal sustainability initiatives, only few programs extend across companies in a structured way. Albino et al. (2009) found SSCM to be the least adopted sustainability strategy in a sample of companies listed in the Dow Jones Sustainability World Index (DJSWI). This result is even more meaningful as companies in the DJSWI are assumed to be sustainability leaders and thus should be considered state of the art in sustainability implementation. Furthermore, Albino et al. (2009) find that internally focused energy efficiency initiatives are the primary focus for companies in their sample. Consequently, their results provide additional support for the notion that even among companies with an independently established strong sustainability focus, SSCM practices are not commonly implemented across companies. Although a practical lack of SSCM integration is therefore well documented empirically, an understanding of this lack of implementation and insights into how to change this situation remain elusive.

Concerning the role of certification for SSCM, Rondinelli and Vastag (2000) point out that the implementation of certification from the ISO 14000 family alone does not guarantee sound sustainability performance. Bansal and Hunter (2003) empirically show that ISO 14000 certification will be more likely pursued by companies who are already concerned about sustainability than by those that are heavy polluters. Although certification is therefore a good indicator for advanced sustainability practices, ISO

14000 is ill-equipped to foster diffusion of the sustainability concept across companies. Potoski and Prakash (2005) demonstrate that ISO 14000 lends itself well to a reduction in the necessary effort for compliance with environmental and social regulation, but is not of much benefit to implementing sustainability outside of compliance issues, thus falling short of holistic SSCM implementation.

Connelly et al. (2011b) argue that the theoretical foundations for sustainability in businesses are comprised of several theories. Similarly, Carter and Easton (2011) explicitly recommend the use of multiple theories when engaging in research around sustainability to improve the depth of the analysis. In a recent piece, Seuring (2011) argues that SSCM theory changes the application of general SCM theory as certain criteria and assumptions (e.g., concerning sourcing decisions) are altered by expanding the view from the single to the TBL. Thus, current management theories will augment this study's data in support of deriving a typology for SSCM implementation. A selection of theories suggested by Carter and Rogers (2008), Connelly et al. (2011b), and Carter and Easton (2011) with high relevance for SSCM is presented in Table 1. The selection of theoretical lenses displayed in Table 1 will be applied in the description of this study's findings to derive theoretically sound implications. The findings are mirrored with theory to gain further insights into the relevance of the findings as well as to provide suggested advancements of the theory based on the analysis.

METHODOLOGY

As established through the literature review, the theory around implementing SSCM is still abstract and broad in nature (Faber et al. 2005). As argued by Lubin and Esty (2010), this results in implementation of sustainability efforts that are characterized by a lack of structure. Thus, consistent with the suggestions of Fawcett and Waller (2011), this study was conducted to seek clarity around sustainability implementation in companies and supply chains rather than confirm preconceived ideas. Starting from the empirical data, a theoretical framework is derived and then mirrored with existing theories and literature. A qualitative research design (Easterby-Smith et al. 2002; Frankel et al. 2005) was deemed appropriate given the goals of the study. In particular, a grounded theory (GT) approach is taken, based on the fact that it is designed to explore complex phenomena in real-life situations (Glaser and Strauss 1967). As the implementation of the theoretical concept of sustainability across supply chains is being investigated and the authors have a strong desire to conduct research of high managerial relevance, GT suits the topic in question (Glaser 1999; Mello and Flint 2009).

GT was established by Glaser and Strauss (1967) and further refined by many authors, for example Glaser (1978), Goulding (1999, 2000, 2002), Corbin and Strauss (1990, 2008) and Charmaz (2006). Following the suggestions of Pratt (2008, 2009), an explanation of how sampling, data collection, and analysis were conducted and how research validity as well as ties to existing theory was ensured is provided. Further guidance on how to employ GT for business logistics and economics research beyond the scope of this section can be found in Mello and Flint (2009), Maital et al. (2008), Flint et al. (2005), Wilson (2002) and Finch (2002).

Table 1: Theoretical lenses for this paper

Theory	Role with respect to sustainable supply chain management (SSCM)	Sources
Stakeholder theory	The fundamental concept of stakeholder theory is to extend the view of a firm's constituents beyond the direct representatives and the shareholders. Primary stakeholders are actors with direct influence on the company (e.g., customers, suppliers) while secondary stakeholders can affect the company through influence on the primary stakeholders (e.g., nongovernmental organizations). All supply chain (SC) partners are thus stakeholders of the focal company.	Agle et al. (2008); Garvare and Johansson (2010)
Resource dependence theory	Companies' decisions depend not only on rationality but also on power. Furthermore, companies attempt to reduce resource constraints, namely from single suppliers for a resource—either by diversification or by taking control of the resource themselves. As dependency increases, firms should attempt to also increase control and integration to ensure sustainability of the resource.	Casciaro and Piskorski (2005); Carter and Rogers (2008); Davis and Cobb (2009); Hillman et al. (2009); Connelly et al. (2011b)
Transaction cost economics	Transaction costs (TCs) incur for monitoring the sustainability performance of SC members. TCs are perceived to be a major barrier for implementation of SSCM.	(Carter and Rogers (2008); Connelly et al. (2011b))
Signaling theory	Communicating SSCM activities is often costly. Sustainability marketing is threatened by greenwashing. SC-integration of sustainability efforts is crucial to sending a uniform signal as a SC.	(Connelly et al. (2011a,b))

Sampling and data collection

Over the span of 15 months, in-depth semistructured interviews were conducted with 28 companies in the United States and Europe. As some interviews involved more than one company representative at a time, a total of 36 people with varying backgrounds were interviewed. An interview guideline was used to initiate the discussions (Patton 2002); however, care was taken to always react to themes and topics as they emerged. The interviews were carried out in person whenever possible and ran for 45 min on average. All interviews were recorded and then transcribed. The transcriptions were the basis for the analysis. As the authors performed the transcription, accuracy and correct use of terminology were secured.

Theoretical sampling (Corbin and Strauss 1990; Goulding 2000; Charmaz 2006; Breckenridge and Jones 2009) was employed. Theoretical sampling bases the selection of participants on the prospect of adding new approaches and inputs to the study as well as saturating categories, thus driving sampling by theory as it emerges (Glaser 1978; Goulding 2000). The focus is on gathering rich data, not achieving statistical validity (Barbour 2001; Charmaz 2006). Sampling, data collection, and data analysis are carried out simultaneously and the activities are interrelated (Corbin and Strauss 1990; Glaser 2002; Suddaby 2006). For this study, sampling decisions were based on the goal of providing a diverse picture of different perspectives and respondents. The interviewed companies therefore represented a cross-section of industries. The interview participants also came from diverse functional positions, such as operations, logistics, sustainability, and corporate social responsibility (see Table 2).

An initial sample consisting of five companies provided a sound starting point for validating the design of the interview guideline and provided a survey of the topic (Charmaz 2006). After these initial interviews, the guideline was adapted to further specify the topic in question and include emerging categories. The guideline was again modified after additional interviews were completed as themes began to be distinguished more clearly. A final modification to the guideline was made after the 15th interview (the lead author will provide the different versions of the interview guideline upon request). Additional theoretical sampling was conducted after each of the changes.

In addition to the interview data, secondary information about sustainability activities within the participating companies was collected. Most of this information came from corporate sustainability reports and data that were made available publically on the web. In several cases, interviewees provided internal presentations and memos. This secondary data (data triangulation) made verification of the information from the interviews possible and added objectivity to the data (Glaser and Strauss 1967; Böger 2010).

Data analysis

Parallel to data collection, data analysis was conducted through coding activities (Glaser 1978; Charmaz 2006). Multiple researchers analyzed the data simultaneously to improve validity and reduce the impact of potential individual biases (Corbin and Strauss 1990).

According to Charmaz (2006), coding should be conducted in three stages: initial coding, focused coding, and theoretical coding. During initial coding, analysis was performed very close to the

Table 2: Overview of the sample

No.	Industry	Region	Respondent position/department
1	Consulting	Europe	Consultant
2	Food and Retail	Europe	(1) Head of Sustainability and (2) Representative from the Logistics Department
3	Consumer Electronics	Europe	General Manager Logistics
4	Retail	Europe	Head of Logistics
5	Chemicals	Europe	Supply Chain Management
6	Food	Europe	Chairman of Executive Board
7	Food	Europe	(1 and 2) Logistics Management, and (3) logistics service providers of interview partner
8	Food and Retail	U.S.	(1) Customer Service, (2) Head of Logistics, and (3) Head of Sustainability
9	Logistics	Europe	Global Head of Green Logistics
10	Logistics	Europe	(1) Senior Director Logistics and (2) Head Business Development
11	Logistics	Europe	Head of Green Logistics
12	Retail	Europe	Division Management CSR
13	Logistics	U.S.	Head of Sustainability
14	Industrial Products	U.S.	Vice President of Global Sustainability
15	Paper	Europe	Head of Group R&D
16	Apparel	U.S.	Head of Logistics and Supply Chain Management (SCM)
17	Home Appliances	U.S.	(1) Head of Sustainability and (2) Logistics and Supply Chain
18	Medical Supplies	U.S.	(1) Category Management and (2) Warehouse and Logistics
19	Food	U.S.	Supply Chain Management
20	Food	U.S.	Product Design
21	Automotive	U.S.	Product Design
22	Logistics	U.S.	(1) Human Resources and (2) Internal Consultant
23	Food	U.S.	Head of Logistics and SCM
24	Consulting	U.S.	Consultant
25	Food	U.S.	(1) Supply Chain Management and (2) Product Design and Packaging
26	Industrial Products	U.S.	Logistics and Supply Chain
27	Food	U.S.	Corporate Social Responsibility
28	Sporting Goods	U.S.	Operations and Logistics

data and the interview transcriptions were approached without direct consideration of existing theory (Corbin and Strauss 1990; Charmaz 2006). The data was broken down to make it more accessible for constant comparisons (Glaser and Strauss 1967; Fendt and Sachs 2008). Open coding resulted in approximately 1,800 codes. During the coding process, certain groups of codes with close ties emerged and consequently categories were formed.

During the focused coding phase, all codes were reviewed and further generalized (Charmaz 2006). The most frequently used codes were examined for their adequacy and renamed if necessary to include higher level concepts (e.g., when differentiating approaches by companies how sustainability programs were introduced into their supply chain, “push” and “pull” approaches were termed with the higher level concept “initiation”). This activity was not carried out in a linear fashion, but instead went back and forth to the data as more abstract concepts emerged.

The final coding phase—theoretical coding (Charmaz 2006)—aims to reassemble the data fractioned in the initial coding process and thus foster the deduction of general themes. In this phase, the data were regrouped to create the proposed typology for SSCM implementation. The analysis provided an ability to assign more generic categories and reevaluate the typology repeatedly to derive strong connections between the concepts established (Corbin and Strauss 1990).

Saturation and sample size

Data collection was concluded when category saturation was reached. The main indicator for saturation is the lack of new aspects being revealed through additional data collection (Goulding 2002; Patton 2002; Charmaz 2006; Corbin and Strauss 2008) in combination with constant comparison not indicating the existence of new properties within the categories (Holton 2010). As data analysis revealed that the main categories formed a clear picture of companies’ attempts to implement SSCM and that these emerging categories were supported by study participants, it was concluded that saturation had been reached after interviews with 28 companies. Although the number of interviews is not the key indicator of saturation, it should be noted that this amount exceeds the suggested number of eight interviews by McCracken (1988) for homogeneous samples and 12–20 interviewees for heterogeneous samples (Carter and Jennings 2002).

Research validity and ties to existing theory

To ensure high validity, the integrity of the research process was verified employing criteria for qualitative research developed by Mayring (1990). Measures taken to satisfy the criteria are summarized in Table 3.

Table 3: Actions taken to assure research validity

Criteria	Measures taken by research team
Documentation	Detailed documentation of data analysis and rigorous reevaluation of codes with multiple researchers. Use of software to structure and document the analysis.
Using conclusive arguments to validate interpretations	All interpretation of the data is documented and identified as such. Reference to quotations by participants when viable.
Methodological rigor and systematic approach	Employment of different stages of coding with reevaluation of categories. Constant comparison of codes with data.
Collecting data from real-life situations	Conducting interviews in person where possible. Semistructured interviews ensured openness to new aspects versus inflexible questionnaires.
Evaluation of results with participants	Concepts that emerged throughout the interviews were discussed with following participants.
Triangulation	Data triangulation with secondary data like sustainability reports. Researcher triangulation.

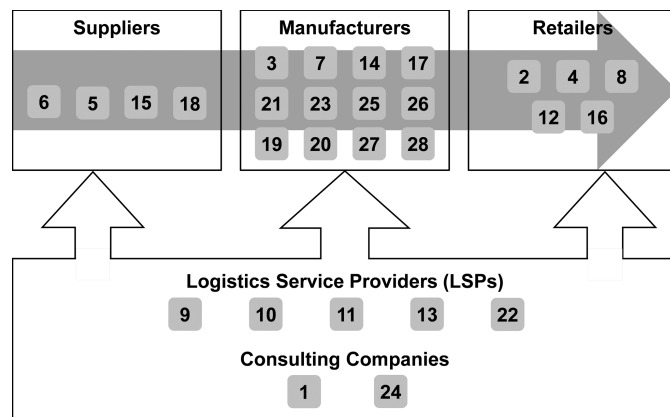
Table 4: Measures taken to ensure high quality of theory development

Criteria	Measures taken by research team
Credibility <i>Results must be adequate representations of the data</i>	Theory directly grounded in the data Interview and research process of 15 months allowed for detailed data analysis at every stage of the process Simultaneous analysis and data collection allowed for feedback and cross-checks
Transferability <i>Applicability of results to larger population</i>	Theoretical sampling Only reoccurring themes were transferred into theory
Dependability <i>Stability and consistency of results regardless of time and place</i>	The collective experience of all participants was tapped into for the study, providing a large body of know-how International nature of the study reduces strong regional impact International research team reduces potential regional researcher bias Long data collection process ensures avoidance of ad-hoc conclusions
Confirmability <i>Results are grounded in actual data versus driven by researcher bias</i>	Researcher triangulation Feedback of results with participants
Integrity <i>Results are influenced by reality and not intentionally misguided by participants</i>	Anonymity was guaranteed to all participants Interviews were conducted in a nonthreatening manner Data triangulation

Continued.

Table 4: (Continued)

Criteria	Measures taken by research team
Fit <i>The results are significant and meaningful for the topic under investigation</i>	Interviews were conducted in an open manner, allowing for participants to raise issues of importance to them All theory is directly taken from data
Understanding <i>The respondents understand the conclusions derived by research team</i>	A summary of the interviews was given to all participants as well as colleagues and practitioners for review Working results were presented on conferences (POMS 2010) and workshops (workshop about sustainable products at Indiana University, 14th–15th October 2010) and feedback was included
Generality <i>The findings cover the subject under investigation in a holistic fashion and include multiple dimensions of the topic</i>	Semistructured interviews were open and of sufficient depth to allow for multiple aspects of the issue to be discussed Interview guideline was adapted to include further aspects as pointed out by the participants
Control <i>Participants have an influence on developed theory</i>	Executives of multiple different functional backgrounds were interviewed about their take and input on the topic Focus on possible influence of participants' companies and their role in the supply chain

Figure 2: Sample-companies' positions in the supply chain.

Research validity was evaluated following the view of Glaser and Strauss (1967) that the quality of theory developed using this approach is highly dependent on its generation process. The approach was verified for GT generation following the criteria of Glaser (1978, 2002) as refined and expanded by Flint et al. (2002). Efforts to ensure high quality of theory development and methodological rigor are summarized in Table 4.

FINDINGS

Companies interviewed for the study represent the different roles of a generic supply chain: suppliers, manufacturers, retailers, and LSPs. The generic supply chain employed here is an adapted version

of the extended/ultimate supply chain model established by Mentzer et al. (2001). These terms will be employed in the remainder of this paper to identify the position of a company in the supply chain. As companies from different continents and industries were interviewed, the sample provides coverage of the different roles and views in a supply chain (see Figure 2).

With all interviewed companies, their individual understanding of sustainability was discussed at the beginning of the interview. Thus, use of common terminology during the interviews could be ensured. The understanding of the concept of sustainability in all interviewed companies resembled the TBL approach. The concept of viewing sustainability from a social, environmental, and economic perspective resonated well with the participants and was found to be an accessible approach as has also been suggested by Carter and Rogers (2008). All participants stressed that a potential positive impact on the economic bottom line was an imperative for pursuing an initiative as companies will: *...do all the things that make sense for the planet that have an economic payback*. (Interview # 23, Food, U.S.) This attitude directly supports the economic impact paradigm put forward by the employed SSCM definition established by Carter and Rogers (2008) and therefore further supports the adequacy of the current definition.

In accordance with the GSCM and SSCM literature summarized in the literature review section, the participants claimed that they felt that pursuing sustainability would help their companies build a competitive advantage in the future. Therefore, all participants had already started engaging in sustainability initiatives within the realms of their organizations. However, a lack of cooperation with other members of one's supply chain with respect to sustainability was identified in the current sample, as also suggested by the research summarized in the review of the extant literature (e.g.,

Figure 3: Typology of the supply chain approach toward sustainability.

Mandated	Collaborative
<ul style="list-style-type: none"> • Time horizon: Short/medium term, no supplier development • Implementation: Dyadic, formal • Split of Benefits: Disproportionately • Initiation: Pulled by the upstream SC partners (retail) • Communication: Low level, formal • Internal implementation: Driven by short term cost reduction or marketing opportunities 	<ul style="list-style-type: none"> • Time horizon: Long term, calling for extended supplier development • Implementation: Integrated, formal and informal • Split of Benefits: Proportionately • Initiation: Engaging SC partners • Communication: High level, formal and informal • Internal implementation: Driven by desire to achieve long term competitive advantage

Sabath and Fontanella 2002; Barratt 2004). Baird and Rowen (2010) attribute the lack of reaching out into the supply chain to the fact that companies in their sample viewed outsourced processes and logistics to be beyond their direct control and they preferred to focus on their own operations. In accordance with this, the participating companies of this study tended to have a strong internal focus and showed only limited, sporadic activity aimed at extending sustainability initiatives across their supply chain.

If companies did, in fact, extend their sustainability efforts into their supply chain, the focus with respect to sustainability can be differentiated into what can be termed “mandated” or what can be termed “collaborative.” To achieve more clarity around this apparent disconnect between perceived importance and actual implementation, a typology of SSCM implementation is developed. In accordance with Carper and Snizek (1980), Marradi (1990), and Rich (1992), the term “typology” is employed, because this is a multidimensional classification scheme of the implementation approach. The proposed typology also provides direction for further research activities and the associated propositions are detailed as they emerge. An overview of the typology is presented in Figure 3 and will be further explained in the following paragraphs. In support of the propositions that emerge around the typology, statements from the participants are incorporated into the text. In addition, further proof-quotes for each of the propositions are provided.

“Mandated” implementation of sustainability in the supply chain

The data strongly support the view that if companies reach beyond their own borders, they are currently doing so in a mandated fashion. Mandated sustainability initiatives are usually initiated by the retailers (buying firm) in the supply chain and then extended to the upstream members (selling firm), as this participant reports: *normally we approach the supplier and say*

‘hey you know for us it is a very important topic and by the way, reducing your energy input could even save your money’ (...). So it is mostly a matter of us persuading and convincing them to tackle some of the points that we show them (Interview # 12, Retail, Europe). Organized in the form of dyads, this cooperation only involves companies in subsequent tiers in the supply chain. It was the perception of the participants in the study that the initiatives were implemented in this way across the supply chain because only the stronger and more powerful members of the chain could initiate such initiatives as this participant explains: *our ability to push an agenda on sustainability to our retailers is relatively small. That is the same environment that exists with our suppliers. So it is a pull process. And it starts with leadership and the folks who have the leverage to get things done. Clearly speaking, most of our suppliers do not have that leverage* (Interview # 14, Industrial Products, U.S.). Based on the current statements (see also Table 5 at the end of this section) and the aggregated data analysis, the following proposition emerges:

Proposition 1

Sustainability efforts are currently implemented in a mandated fashion as a pull process through the supply chain and initiated by the stronger members of the chain.

Mandated sustainability initiatives are usually implemented on a formal “here is what we need you to do” basis. A good example of this is the use of codes of conduct a retailer requires their manufacturer, supplier, or LSP to sign to establish a business relationship as this participant notes: *usually the customers have a policy we have to sign or we fill out a questionnaire. There is not really a discussion* (Interview # 9, Logistics, Europe). This form of implementation can be labeled “mandated” because it does not involve much two-way conversation or sharing of best practice or experience as the following participant

Table 5: Proof-quotes for the emerging propositions

Further support for Proposition 1	<p>“I would say, at this point it is on our end. We have a lot of reaching out to suppliers to do (...) these are all things that we have initiated.” (Interview # 18, Medical Supplies, U.S.)</p> <p>“From a supplier perspective, they have never come to us. It is us coming to them. We’ve had no push from the supplier perspective. So it’s this trickle-down effect, we are a big supplier to some retailers, who have put us in their high-risk, highly monitored kind of group and we have replicated that process with our supply base. But generally speaking, our suppliers are not pushing this topic at all.” (Interview # 14, Industrial Products, U.S.)</p> <p>“The bigger companies can pretty much get suppliers to create whatever they want or at least consider it. With us, if it is not something that is emerging or readily available they are not creating it. Only in very few cases, folks are going to create something special for us because of our [small] size.” (Interview # 23, Food, U.S.)</p>
Further support for Proposition 2	<p>“Our suppliers are always involved and quite frankly, we are very tough on our suppliers. We do supplier challenges. You go out to current suppliers and potentially new suppliers and tell them what you are looking for. (...) We definitely take advantage of the resourcing, insights and capabilities that our supplier have.” (Interview # 20, Food, U.S.)</p> <p>“We haven’t had a lot of success to be honest with you. The suppliers will call and promise the world and when you sit down and dig down, in every case we’ve had so far, they are not really much further ahead than the folks we are dealing with now. There is a lot of greenwashing going on and a lot of self-promoting.” (Interview # 23, Food, U.S.).</p>
Further support for Proposition 3	<p>“I was invited to a sustainability workshop at a company recently and they just kept talking about prices for the logistics lanes in their last tender. Then somebody got up and asked if this was about sustainability or about prices and they admitted that it was just pricing negotiations but they knew we’d show up for sustainability talks...” (Interview # 7, logistics service providers of interview partner, Europe).</p> <p>“Something that deeply impressed me, (...) there were customers who had been evaluating the company and conducted a benchmark and we were in the top segment environmentally...and then finally they give you no business and make their contracts with the cheapest company.” (Interview # 10, Logistics, Europe)</p>
Further support for Proposition 4	<p>“We are moving to this notion of shared benefits and shared responsibility and that is really the key to a good relationship with any outside vendor. (...) As far as hiding the benefits of those things in partnerships, that doesn’t work. So we are really trying to roll that out across the company, this notion of shared benefits.” (Interview # 8, Food and Retail, U.S.)</p> <p>“In terms of collaboration, what I am seeing this far is that a lot of companies want to get together and not just discuss: what is our sustainability strategy? But they want to look at what organizations are doing, independently or collectively to be more sustainable and seek opportunities to collaborate. I think one other plus side from just leaning your operation (...) sustainability in a macro view really is about collaboration on one level in order to agree upon the processes, procedures and technologies that are used to move products around the globe.” (Interview # 13, Logistics, U.S.)</p> <p>“I think what I would do (...) is horizontal integration. Because I think for example trucks in Europe are on average only 20–30% full of cargo. So a huge opportunity lies in collaborating in the supply chain. But obviously there are severe obstacles; companies do not want to share data or any information about their supply chain. So I think there is a lot of work to be done in this area.” (Interview # 9, Logistics, Europe)</p> <p>“...if I sat at my desk alone, I would not have these ideas, but if you go out to talk with carriers and service providers, industry at conferences or whatever, talk to your own people; the network in Europe is big enough; then you get new ideas and some of them are really great.” (Interview # 3, Consumer Electronics, Europe)</p>

indicates: *we were in a meeting with a retailer 2 years ago. They said: ‘You WILL [emphasis added] provide us with a sustainable product’. We won’t forget. It wasn’t a question; it wasn’t a request; it was a statement* (Interview # 17, Home Appliances, U.S.). Communication around sustainability in a mandated initiative is often characterized by strict instructions that are made by the dominant party. Commonly, the communication is focused on economic aspects rather than truly broaching sustainability topics as this interviewee illustrates: *my feeling is that they are*

approaching us but not on a constructive basis that they honestly want to make suggestions or know what they are talking about or want to discuss. They are basically approaching us with a slim commercial line (...) and they just want to show off that they have less greenhouse emissions or whatever. So that is not what I feel is some kind of working together, it is more just a simple commercial pressure that is put on somebody and on the company (Interview # 10, Logistics, Europe). Based on these findings, the following proposition is established:

Proposition 2

Mandated sustainability implementations are characterized by a lack of communication and collaborative behavior.

The powerful members in the supply chain (typically retailers in this study) generally strive to capitalize on short- to medium-term cost reductions or marketing opportunities. Rather than developing a long-term competitive advantage for the supply chain as a whole, in case of mandated implementation, the low hanging fruit of working with the manufacturers is harvested by the retailer. The main motivation as a manufacturer or supplier to engage in this form of SSCM implementation is generally not to improve their own sustainability performance, but to comply with retail requirements. Consequently, these efforts can often be characterized by a lack of buy-in by the manufacturer, supplier, or LSP forced to implement the initiative because there is no or limited internal benefit on their side. The cause of this situation lies in the fact that a major characterization of mandated initiatives is the disproportionate distribution of the incurring benefits, risks, and investments across the companies involved. Specifically, evidence emerged in the data that companies with major bargaining power in the supply chain use this influence to benefit disproportionately from sustainability activity because: *if you are the power player in the supply chain, you just force all the companies around you to be green and take advantage. That is more common for larger retailers and larger players in the supply chain. So they push the cost onto their suppliers and the actual green improvements are from the suppliers but it is not necessarily more green within the four walls of the larger player in the supply chain* (Interview # 24, Consulting, U.S.). As mentioned in the literature review, work by Lee (2009), Mollenkopf et al. (2010), and Kersten et al. (2010) provide support for this finding.

Although the retailers in strong bargaining positions have the power to force their manufacturers and suppliers to implement certain sustainability measures, they will also demand potential cost-savings be passed on to them entirely and directly. Several suppliers and manufacturers across different industries indicated that they had found their large customers to use sustainability discussions as “code word” for pricing negotiations, arguing the suppliers’ sustainability initiatives would lower operating costs due to incurring efficiency gains. In certain cases, suppliers might thus even be hesitant to implement or communicate sustainability initiatives because they fear consequential price reduction demands by their customers. Plambeck (2007) reports similar problems in her analysis of Wal-Mart’s sustainability program.

Especially for generic, easily exchangeable services like basic transportation or warehousing activities as well as low-tech commodity suppliers and companies that are very much dependent on a customer that does not really depend on them, this fear was ever present when talking about sustainability-induced efficiency efforts. Several examples of this perspective emerged in the logistics sector where participants reported that they had become hesitant to fully disclose their sustainability efforts to their customers because they feared price reductions (see quote from interview # 7 in the following section). However, even companies supplying more specific products to retail customers suddenly found themselves facing pricing discussions with their retail partners after successfully implementing a program that saved energy and emissions, for example, in

their warehouses: *the retailer we worked with wanted the cost reductions passed on, that is the underlying thing* (Interview # 27, Food, U.S.). These findings lead to the following research proposition:

Proposition 3

Sustainability efforts characterized by uneven distribution of incurring benefits and risks and implemented in a mandated fashion suffer from a lack of buy-in by the dominated party.

A majority of the interviewees agreed that sustainability cannot yet be considered a standardized differentiation criterion for supplier selection processes even though its importance is widely recognized. Literature supports the importance as well as the lack of practical implementation (Handfield et al. 2002; Baumgartner and Ebner 2010; Wolf and Seuring 2010). A simple explanation would be that companies have just not adapted their institutionalized supplier selection process criteria yet and therefore currently fail to adequately consider sustainability.

Furthermore, many participants mentioned that they had trouble quantifying sustainability and were lacking the tools to assess it as part of their supplier selection process. Support for this notion can be found in the literature (e.g., Handfield et al. 2002; Staniškus and Arbačiauskas 2009; Wolf and Seuring 2010). Another possible explanation of this finding is provided by transaction cost economics (TCE). Companies perceive monitoring costs for a sustainability assessment to be high and thus often refrain from making sustainability issues a selection criterion. As introduced in the literature review, ISO 14000 certification provides a possible alternative to individual sustainability monitoring. Yet, as mentioned previously, ISO 14000 does not fully cover SSCM implementation, certification can only be a positive indicator while companies still have to make costly individual assessments. The role of TCE will be further explored in the implications section.

“Collaborative” supply chain sustainability initiatives

Collaborative sustainability efforts in this paper are defined as a higher level concept. The concept is derived from the statements and views of the participants of the study and represents their “ideal vision” of sustainability implementation in the supply chain. This vision involves at least two companies working jointly for an extended period of time on sustainability initiatives and collaboratively improving their performance on the TBL criteria. Fully implemented instances of this type of approach did not surface during the interviews; however, the participants indicated that they had a desire to get further engaged in these efforts. However, they found this collaboration to be challenging because: *the relationship is critical. To have a truly sustainable product, you have to go up and down the supply chain in both directions. If it is going to be forced on us, the result isn’t going to be as good as if it is partnership, working towards the same vision* (Interview # 17, Home Appliances, U.S.). As collaboration of this kind requires a relationship with a high degree of trust and a long-term perspective, it is most likely to evolve from preexisting strong relationships that are expanding into the area of sustainability.

The main motivation for companies to engage in collaborative sustainability efforts is the opportunity to gain long-term competitive

advantages for their whole supply chain. While participants found it difficult to pinpoint the exact source of the expected competitive advantage, there was consensus among all interviewees that collaborating around sustainability would be beneficial as opposed to more mandated forms of implementation. Existing literature (Steger 1996; Sinding 2000; Sharfman et al. 2009; Seuring 2011) supports the view that collaborative initiatives are preferable to a mandated approach as they are more likely to produce satisfactory results for all parties involved. The following statement provides support for this viewpoint: *Customers approach us very differently. Some just write a letter saying: 'This is what we want, see how you can make it happen. And because we know you will be saving fuel by being more efficient, we will pay you 5% less from now on'. So they are all about the money. Others will try to work with you and find solutions and will share benefits. That makes things a lot easier.* (Interview # 7, logistics service providers of interview partner, Europe). Based on these findings, it is proposed that:

Proposition 4

Sustainability initiatives pursued in a collaborative fashion are more likely to be accepted by supply chain members than initiatives based on "mandated implementation."

IMPLICATIONS, LIMITATIONS, AND FURTHER RESEARCH OPPORTUNITIES

Theoretical implications

As pointed out by Lee et al. (1999) and Pratt (2009), qualitative research and GT in particular is well suited to augment and elaborate existing theory. As stated in the literature review and methodology sections, there is no single "sustainability theory." In Table 1, an overview of a selection of management theories with respect to SSCM implementation is provided. In this section, these theories will be connected to the results of this study. The main research question was to identify how companies involve other members of their supply chain in their sustainability efforts. As the answer to that question, the proposed typology of sustainable supply chain implementation was developed.

The basis of the theoretical analysis is the application of stakeholder theory (SHT) to SSCM because SHT defines the relevant actors and recipients for any sustainability activity (Carter and Easton 2011). SHT explicitly points out that all members of a supply chain have to be considered stakeholders of a focal company. The notion of stakeholders is therefore part of general SCM definitions (e.g., Lambert et al. 2008) and is at the core of the SSCM definition established by Carter and Rogers (2008). The findings of this study support the importance of SHT, as the underlying tenets of the theory were referenced by the participants. Consequently, the data shows that SHT has a wide acceptance among practitioners involved in sustainability issues. On one hand, companies felt a strong push by stakeholders like customers, the government, and nongovernmental organizations to get engaged in sustainability, therefore the expected connection of SHT and sustainability is supported by the data. On the other hand, the strong internal focus held by the companies in the

sample does not fit SHT because companies either do not fully identify other members of their supply chain as important stakeholders with respect to their sustainability programs or at least do not act on this belief if they do. With respect to the statements of the participants supporting a more collaborative approach, the data suggest that companies acknowledge the need to include other members of their supply chain in their sustainability efforts, thus supporting the later conclusion.

An examination of the data suggests that companies currently have a tendency to pursue a mandated implementation approach for sustainability efforts. They use their power over other members of their supply chain to force them to implement sustainability-related measures. In addition, there is a tendency for the buying firm to skim most of the benefits even though many participants suggested that they would consider collaborative approaches to be more successful in the long run. Resource dependence theory can help explain this type of behavior as it predicts firms to use organizational power to reduce dependencies on other supply chain members by loosening relationships or diversifying (Min and Galle 2001; Connelly et al. 2011b).

The current data indicate, however, that the observed behavior can be explained by a simple lack of sufficient SSCM implementation and companies were generally interested in moving in a more collaborative direction and were also slowly starting to do so. This notion is supported by work by Pagell et al. (2010) who find companies that had already successfully implemented SSCM to work much more collaboratively than a supplier selection concept following Kraljic (1983) would suggest. They find companies in their sample to refrain from leveraging the suppliers of commodities, even though standard supplier selection concepts would expect them to do so. Rather, they find a desire for long-term collaborative relationships to progress sustainability initiatives across the supply chain. Although this behavior could not be found in the current data, the participants repeatedly suggested that they were moving in this direction.

Based on this result, the current findings were also analyzed with respect to TCE. Data from this study indicate that collaborative sustainability efforts are understood to facilitate more benefit than mandated implementation approaches—a view reported by all participating companies. This finding supports the views put forward by Seuring (2011) in his recent analysis of SSCM. Seuring (2011) further argues that SSCM implementation strongly depends on increased supplier development and monitoring of performance on a large variety of criteria. Furthermore, he cautions that increased monitoring can lead to rising transaction costs, ultimately possibly even driving costs above the value of the supply itself. If rising transaction costs for SSCM are thus inevitable, yet companies are pressured to grow more sustainable by their stakeholders, collaborative efforts for sustainability are the key to leveraging a joint effort to increase performance of the entire supply chain. Consequently, the findings of the study that collaborative sustainability efforts are preferable to mandated implementation can be supported by TCE as collaboration can be a way to reduce sustainability-related monitoring costs.

In this regard, signaling theory (ST) may also play an important role for transaction costs and SSCM implementation. ST predicts that companies have a rationale for making costly investments to convey a message to the recipient that is difficult

to imitate (Connelly et al. 2011b). As mentioned previously, ISO 14000 certification is a good example of those signaling costs incurred to indicate commitment to the constituents. With regard to both TCE and ST, this study's findings can contribute the approach of leveraging the transaction costs incurred by a sustainability effort. The data suggest that collaborative efforts can be more effective because they generate high levels of buy-in for all parties due to efficient incentives allowing everyone to benefit. As argued in the literature, TCE and ST underline the importance of bringing down the cost of sustainability implementation (Nidumolu et al. 2009; Connelly et al. 2011b). The current data suggest that collaboration provides opportunities to enhance the efficiency and effectiveness of sustainability initiatives, thus reducing the impact of the transaction costs relative to the overall benefits.

Managerial implications

This study provides several findings with high relevance for supply chain managers as well as practitioners in charge of sustainability efforts. Primarily, from the data, it can be concluded that the current level of SSCM implementation and thus the supply chain integration of sustainability initiatives can be considered insufficient. Companies should consider quickly stepping up their involvement with other members of their supply chain in their implementation of sustainability initiatives as this will be an important opportunity to leverage their relationships. Furthermore, the data indicated that most companies currently waste the vast potential of involving other supply chain members in sustainability efforts by not approaching these outside companies in an appropriate way. The current focus on mandated implementation does not allow for sustainability initiatives to generate as much impact as they could because there is a misalignment of incentives. If the less powerful players in the supply chain (often the suppliers) are not allowed to benefit from sustainability improvements, they will not fully endorse initiatives, thus falling short of the potential. Power players in the supply chain should possibly even consider enabling suppliers to contribute more to the sustainability initiatives by helping them with the necessary resource investments. Pagell et al. (2010) find evidence of companies already making sustainability initiatives an important part of their supplier development efforts and also financing investments that their suppliers could not have managed on their own. Although this study did not contain any participants who had experienced efforts in this direction, several interviewees mentioned that they would be willing to explore the possibilities. The results of the study should encourage practitioners to engage in collaborative efforts around sustainability to build long-term competitive advantage for their own company as well as their supply chain.

Limitations and future research opportunities

The selected GT approach for this analysis has provided rich data and meaningful insights into the research question. However, there is a potential limitation of using theoretical sampling. The study did not ask standardized survey questions and has a limited sample size. Thus, the results of this study may not be fully representative of the population. However, findings of GT research can be employed to derive research propositions and make suggestions for further work. Following the examples of Closs et al.

(2010) and Flint et al. (2005), the propositions that emerged from the findings serve as an impetus for follow-up research.

Opportunities also emerge for researchers to empirically analyze sustainability in the supply chain across different industries. Given the wide focus of the article, the analysis did not focus on looking at potential industry differences. Analysis in this direction may prove to be valuable as differences between industry sectors and market types can be expected.

When companies extend their sustainability efforts into their supply chain, the data indicate a "mandated implementation" approach to be prevalent. There were strong indications that this approach may lead to suboptimal results due to misaligned incentives. The research proposition can be employed as starting points for hypotheses examining this idea. Propositions 1 and 2 can be used for a quantitative validation of the mandated implementation of sustainability initiatives. Propositions 3 and 4 provide possibilities to analyze the current misalignment of the incentives in the supply chain as well as develop approaches for collaborative initiatives.

Based on the collected data and in accordance with TCE and ST, collaborative work in sustainability is recommended as described previously and companies are encouraged to press for a fair distribution of benefits, creating win-win situations for themselves and other members of their supply chain. This study provides initial ideas for possible relationships between collaboration and transaction costs that should be further pursued empirically as well as using modeling approaches. Researchers may also want to consider engaging in research around the fundamental question, in what ways intensified collaboration with suppliers as well as customers can enhance the TBL performance of a focal company.

In accordance with general relationship models (e.g., Lambert et al. 2009), companies should carefully evaluate and select their strategically important business partners and approach them with collaborative sustainability opportunities. In terms of potential future research, the need for additional insights into the supply chain dynamics with regard to sustainability emerges. Researchers can provide comprehensive models on how to structure relationships in the supply chain to address the problems of incentive alignment. Partnership models should be expanded to include sustainability issues and provide direction for appropriate ways to allocate benefits and risks across the supply chain.

CONCLUSIONS

Based on the findings and the theoretical and managerial implications, it can be concluded that SSCM implementation is at an early stage of development. Companies have yet to embrace the idea of fully implementing sustainability into their supply chain relationships. The current dominant perspective to focus internally with respect to sustainability cannot produce satisfactory results in terms of TBL performance in the long term. Furthermore, when companies do extend sustainability efforts into the supply chain, they typically take a mandated implementation, which was viewed by several companies as a suboptimal approach. Both from a theoretical point of view and a view supported by the current data, a more collaborative supply chain implementation approach to sustainability, featuring long-term relationships, supplier development, and fair distributions of incurring burdens and benefits promises

enhanced results on all three bottom lines. This conclusion is further supported by the fact that the majority of the respondents indicated that sustainability efforts should not be considered as only a fad or a passing phase, but as a major business trend that will continue to evolve in the years to come. Therefore, companies are encouraged to actively seek out sustainability opportunities and be willing to take risks associated with these efforts. Just like any business trend sustainability requires know-how that can only be acquired through experience.

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