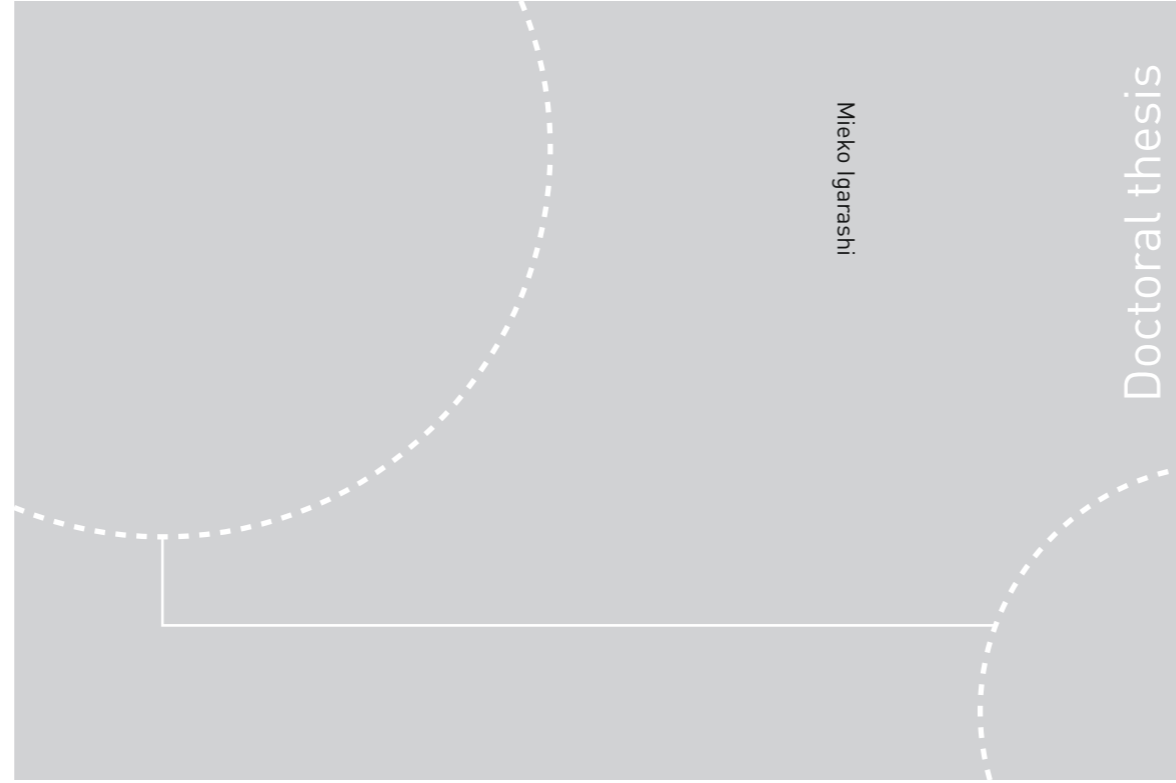


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Mieko Igarashi

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Empirical and conceptual studies of  
environmental criteria in decision-making  
and information processing

 **NTNU**  
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Thesis for the Degree of  
Philosophiae Doctor  
Faculty of Economics and Management  
Department of Industrial Economics and  
Technology Management

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Thesis for the Degree of Philosophiae Doctor

Trondheim, August 2018

Norwegian University of Science and Technology  
Faculty of Economics and Management  
Department of Industrial Economics and Technology  
Management



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*There was a strange stillness. The birds, for example, where had they gone?  
[...]It was a spring without voices. There was no sound;  
only silence lay over the fields, woods, and marsh.*

*(Rachel Carson, 1962)*



## **Abstract**

Green public procurement (GPP) has been a political subject worldwide for more than two decades with the ultimate goal of sustainable development. Because public procurement has huge purchasing power, it is expected to contribute significantly to establishing and enhancing sustainable consumption and production. Recently, pressure has been increasingly placed on the public sector; however, implementing GPP under the legal frameworks of public procurement is not straightforward. The legal frameworks impose transparency, fairness, accountability, etc. on public buyers as well as strict procedures that must be followed. With public procurement already a complex issue before the notion of GPP was introduced, GPP seems to have further increased its complexity.

The existing literature has typically examined the extent of GPP implementation by looking at the inclusion of environmental requirements and criteria in tender documents. Through such research, Norway together with other Northern European countries, has been said to be a leading country of GPP. However, little has been revealed about the actual decision-making process of buyers, and how to cope with challenges and barriers remains unanswered. The objective of this study is to develop a deep understanding of GPP by analysing how buyers make decisions in relation to environmental criteria, and by investigating environment-related information processing in buyers' and suppliers' organisations. The research questions are formulated as follows: RQ1 – What aspects of complexity do buyers face with GPP? RQ2 – How are environmental considerations incorporated into the procurement process? RQ3 – What political and practical insights can we gain for more effective GPP, based on the current practices and issues?

The research approach is primarily qualitative but does not exclude a quantitative approach. The research is a case study of the procurement process in Norway's public sector and consists of four papers, including a literature review (Paper I). The other three papers empirically examine different stages of the procurement process with different foci and different methods. Paper II assesses tender documents and derives the buyer's strategy of including environmental requirements and criteria in the decision-making process, borrowing from the analytical and cybernetic paradigms of decision-making. Paper III elucidates how buyers search and consider information related to possible environmental criteria through a combination of interviews and a

survey. The study observes bounded rationality and heuristics in individual buyer's information searches, as well as identifies contextual factors that are likely to influence buyer's information searches. Paper IV describes how environment-related information is exchanged between buyers and suppliers based on interviews, and how such information is processed by each actor, applying the concept of absorptive capacity.

The main findings are as follows. First, buyers are faced with multiple forms of complexity, at both the strategic level (strategic alignment with the organisation's overall green strategy and handling with the external context) and the operational level (which concrete environmental criteria to choose, how environmental criteria are presented, where in the multiple stages, and tools assist with the decision-making). Second, buyers cope with operational complexities by relying on different types of heuristics. Buyers tend to put weight on information that they are familiar with, that is easily retrievable, and that their peers possess. Third, buyers often try to stay at the minimum, local adjustment level in the green procurement process, meaning that they avoid having environmental award criteria as an independent category with a substantial weight which requires a trade-off with other criteria and needs value integration. Fourth, outcome in GPP can depend on interaction of buyers' and suppliers' absorptive capacity.

Suggestions to buyers include a need for awareness of GPP's complexity, an inclination of heuristics, acknowledging suppliers' perceptions, and understanding the significance of capability development for learning and information processing. Implications for policy-makers include taking behavioural aspects of buyers into consideration, acknowledging that a buyer will likely demonstrate a bounded rational person (or organisation), the need for continuous support and ongoing updates of the current environmental criteria guidelines to stimulate continuous improvements in GPP practices, and lastly, more involvement of suppliers. This research contributes to public procurement research by advancing the current knowledge of GPP by adopting theories/concepts from two different fields – behavioural decision-making and information processing.

## **Acknowledgement**

This research project was funded by the Norwegian University of Science and Technology. Additional funding was provided by the International Purchasing and Supply Education and Research Association (IPSERA) and the Norges Techniske Hogskole Fond. I thank these organisations for offering me this great research opportunity.

I was fortunate to have some streams that led me to the PhD position. First, I would like to show my deep gratitude to Professor Edward Hertwich, then director of the Industrial Ecology Programme, NTNU and incumbent professor at Yale University, for giving me the opportunity to study as an intern at Industrial Ecology in 2009. My gratitude also goes to Troy Hawkins, who was then the post-doc researcher at the Industrial Ecology Programme, NTNU, and trained my research and language skills. I also would like to thank people at Industrial Ecology for their kind and warm welcome. This was my first connection with NTNU.

I am also grateful to Professor Annik Magerholm Fet at the Department of Industrial Economics and Technology Management (IØT), NTNU, who gave me an opportunity to work as a research assistant under the Innovation in Global Maritime Production (IGLO) project in 2010. Through that experience, I practised organising the research process, writing academic reports, and giving presentations, before starting my PhD. I also thank IGLO members for sharing fruitful and enjoyable times at seminars.

It was my husband, Kei, who actually found the announcement for a PhD position at IØT and encouraged me to apply. Caroline Cheng, a colleague in the IGLO project, introduced me to Professor Luitzen de Boer, my main supervisor, which I greatly appreciate. Luitzen has been very supportive since the application preparation stage. I was concerned about how hard surviving a PhD would be at the beginning, but soon I came to believe that I could conduct interesting and significant research with him. I always enjoyed discussions with Luitzen. He inspired me about theoretical concepts, and he helped me find or gain access to cases. He also has been a confidence builder. I feel a profound sense of gratitude to him.

My two other supervisors are Professor Annik Magerholm Fet, whom I mentioned earlier, and Dr. Ottar Michelsen, then research coordinator at the Industrial Ecology Program. I am grateful to them for having warmly watched over my growth as a



researcher, providing input when I needed and encouraging me. I am thankful to getting to know Dr. Gerit Pfuhl, then post-doc researcher at the Department of Psychology at NTNU. Paper III would not be completed without her expertise in the survey method and her inspiring me with concepts from the cognitive science.

I would also like to express deep appreciation to those who spared their valuable time for the interviews. Especially, I would like to mention Bjørn Henrik Hellandsjø, who devoted many hours and allowed me to learn about public procurement, and Magnus Sparrevik, associate professor at IØT, who helped me gain access to one of the case organisations. I also greatly appreciate Dr. Christine Hassenstab's help with the English language, both speaking and writing, in the early years of my PhD period.

My research work has been independent and solo in the sense that my research does not belong to any large projects. I obtained encouragement and stimulation through chats with my colleagues in the corridors, in the office and during lunch. Those people include Lise, Jonida, Godfrey, Marta, Nyhien, Ann Elida, Øyvind, Marte, Marte DQM, Marius and many others. In addition, I feel strong gratitude towards my dearest friends in Trondheim who listened to me and shared difficult times with me – especially, Yaqin, Peggy and Blanca. Further, without friends from Mariners Church, I would not have been able to get through the hardest time that I faced after moving our family base from Norway to the United States.

Last but not least, I thank my family – Kei for calming me when I was very nervous before conferences and for taking on much more responsibility at home than when we lived in Japan to allow me to work on the research while he was also working hard in Mosers' lab. I am thankful to my children, Mari and Akira, and their adorable smiles and healthy growth, who are a source of energy for me.

With deep appreciation,

A handwritten signature in blue ink that reads "M. Eiko Igarashi". The signature is written in a cursive, flowing style.

Irvine, California, January, 2018

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## **List of papers**

This thesis is based on the following papers which are referred to in the text by their Roman numerals.

### **Paper I**

Igarashi, M., de Boer, L., & Fet, A. M. (2013). What is required for greener supplier selection? A literature review and conceptual model development, *Journal of Purchasing and Supply Management*, 19(4), 247–263.

### **Paper II**

Igarashi, M., de Boer, L., & Michelsen, O. (2015). Investigating the anatomy of supplier selection in green public procurement, *Journal of Cleaner Production*, 108, Part A, 442–450.

### **Paper III**

Igarashi, M., de Boer, L., & Pfuhl, G. (2017). Analyzing buyer behavior when selecting green criteria in public procurement, *Journal of Public Procurement*, 17(2), 141–176.

### **Paper IV**

Igarashi, M. (in press) Information exchange and processing in buyers and suppliers in green public procurement: An absorptive capacity perspective. In L. de Boer and P. Andersen (eds.), *Operations Management and Sustainability*. Palgrave Macmillan

\*Please note that Paper III is written in American English, because the paper was submitted to a journal that is based in the United States of America. Other papers and this thesis are written in British English.

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Table 1 Different environmental considerations taken in the procurement process

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## **Notes on the use of terms**

Buyer : both individual and organisational buyer can be meant in the text

Buying authority : an organisation who buy goods or services

Buying officer : an individual who is in charge of procurement project

Supplier: supplier organisation

When a person in a supplier company is meant, a title or other clear expression is used

## **1. Introduction to the thesis**

### 1.1 Background and motivation

Green procurement, or in other words, environmentally responsible procurement, has been the area of my profession and one of great interest for more than a decade. The first opportunity to be involved in the field was given to me when I was working for a company in Japan. I loved my work, being in charge of promoting environmentally friendly production and environmental management systems at suppliers. I learned about many environmental issues that companies, especially manufacturing firms, should acknowledge in order to being responsible as citizens of the earth. Also, I experienced how important the procurement function could be to a company seeking environmentally or socially responsible ways of managing. When I discovered that green procurement was one of the hot topics in the purchasing and supply management discipline, I thought I should step into that academic area. I encountered a study on green public procurement (GPP) that was being conducted by my future supervisors, Luitzen de Boer and Ottar Michelsen. Thus, it was natural for me to commit my PhD study to GPP, with the aim of establishing better contributions of GPP in society.

GPP has typically been addressed in the wider concept of sustainable development or sustainability. In 1983, the World Commission on Environment and Development was set up as an independent body by the United Nations (UN) and headed by Gro Harlem Brundtland, then Prime Minister of Norway. The Commission defined the term *sustainable development* using a multi-disciplinary connotation, which states: ‘sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs’ (World Commission on Environment and Development, 1987). This is usually regarded as the starting point of political discussions on sustainability.

In 1992, Agenda 21, a framework that nations and governments can strictly adhere to, was established at the UN Conference on Environment and Development in Rio de Janeiro. Agenda 21 addresses changes in consumption patterns as a potential area for contributing to sustainable development. ‘They (governments) therefore review the purchasing policies of their agencies and departments so that they may improve, where possible, the environmental content of government procurement policies . . .’ (United

Nations, 1992, p. 21) Following this, a 10-year framework of programs on sustainable consumption and production was established after being called for by the World Summit of Sustainable Development in Johannesburg in 2002, and it focuses on sustainable public procurement together with six other schemes.

The world's latest forward movement toward sustainable development would be the new Sustainable Development Agenda. On 25 September 2015, it was unanimously adopted by 193 member states of the UN. Governments, businesses and civil society together with the UN have started to mobilise efforts to achieve the Sustainable Development Agenda by 2030. The agenda includes 17 sustainable development goals. Among these goals is to ensure sustainable consumption and production patterns. Thus, it has been more than two decades since sustainable consumption and production, and more specifically, public procurement, was first addressed as a significant area to achieve sustainable development.

Not only the UN but also the European Union (EU) has been focusing attention on public procurement in sustainable development as the ultimate goal. A EU communication on sustainable consumption and production (Commission of the European Communities, 2008) addressed the potential role of public procurement in stimulating the better performance of products. Another initiative of the EU can be found in the Integrated Product Policy (Commission of the European Communities, 2003). This policy is aimed at reducing resource use and the environmental impact of waste, which should be implemented in co-operation with businesses – the production side. Governments act directly on markets, for instance, by purchasing greener products to reduce resource use and the environmental impact of waste. EU member states were officially encouraged to draw up national action plans for GPP until the end of 2006 (Commission of the European Communities, 2003, p. 12).

Thus, public procurement has been seen as a link between the production side and the consumption side. Public authorities in every country are major consumers with a financial spend varying from 10% to 20% of the GDP, and generally 19% in EU member states (European Commission, 2011) and 12.3% in Norway (OECD, 2015). Because of this purchasing power, public procurement can have a huge impact on sustainable consumption and production patterns. It not only determines the CO<sub>2</sub>

emissions and other environmental impacts embodied in purchased goods and services, but public procurement also encourages vast supply chains to develop greener products and services (Preuss, 2007). Public authorities can also stimulate green procurement practices in the private sector (Guercini, La Rocca, Runfola, & Snehota, 2015).

According to the definition by the EU, GPP is defined as:

. . . a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured. (Commission of the European Communities, 2008, p. 4)

It should be noted that different terms are used for the same procurement mechanism. Terms used in the existing literature include ‘environmentally preferable purchasing’ (Coggburn & Rahm, 2005), ‘environmentally responsible procurement’ (Li & Geiser, 2005) and ‘sustainable public procurement (SPP)’ (Brammer & Walker, 2011; UNEP, 2014). SPP, by definition, encompasses the three pillars of sustainability – social, environmental and economic aspects. The definition by UNEP (2013) states:

A process whereby organisations meet their needs for goods, services, works and utilities in a way that achieves value for money on a whole life basis in terms of generating benefits not only to the organisation, but also to society and the economy, whilst minimising damage to the environment. (p. 7)

In Europe, policy discussions concerning sustainable procurement are dominated by the environmental theme (Brammer & Walker, 2011), and organisations often implement GPP as part of a broader approach to sustainability in their procurement. This would explain why we often see research where the author’s focus is on the environmental aspect, but they use the label SPP.

This study specifically looks at the environmental considerations/practices in the procurement process. The term ‘green’ is used interchangeably with ‘environmental’ through the thesis.

Environmental pressure on public procurement professionals is continuously increased (Thai, 2001). GPP has been attracting more expectations as a policy instrument as well as a technical tool, and in the last decade, the use of environmental criteria in public tenders has been increasingly diffuse (Testa, Iraldo, Frey, & Daddi,



2012). However, there is a gap between research and practice. I will explain the research status in detail in the next section.

## 1.2 Research objectives and questions

According to the growing political discussion about the promising power of public procurement on sustainable development as described above, initiatives for greening public procurement at national and local levels have been launched in a number of EU member states (Commission of the European Communities, 2001). Monitoring reports and academic articles on GPP have gained momentum, but their amount and the insights provided are still limited compared to green procurement investigated in the private sector (Amann, Roehrich, Eßig, & Harland, 2014). Some have assessed the extent to which green criteria are used (Bouwer et al., 2005; Brammer & Walker, 2011; CEPS & College of Europe, 2012; Kippo-Edlund, Hauta-Heikkilä, Miettinen, & Nissinen, 2005; Michelsen & de Boer, 2009), while others have explored the drivers and the barriers of GPP on individual, organisational and inter-organisational levels (Geng & Doberstein, 2008; Grandia, Steijn, & Kuipers, 2015; New, Green, & Morton, 2002; Testa et al., 2012; Walker, Di Sisto, & McBain, 2008). However, little research elucidates how decisions are made in practice by buyers that lead to the inclusion of environmental criteria. Further, investigations of GPP as an interaction between buyers and suppliers is absolutely deficient, and we know very little about how environment-related information is used by both buyers and suppliers.

Thus, the main objective of this study is to develop a deep understanding of GPP by analysing how buyers make decisions in relation to environmental criteria and investigating environmental related information exchange between buyers and suppliers organization.

The basic concept of GPP relies on having clear and ambitious environmental criteria for products and services (Commission of the European Communities, 2008). Then, supplier selection is of great importance, because this presents an opportunity to include certain environmental criteria in the decision-making process. This thesis calls

this specific procurement part green supplier selection (GSS). Despite providing this opportunity to have less of an environmental impact, including environmental criteria in supplier selection adds to its complexity, because additional information must be gathered and processed. Buyers need to decide how many and what precise characteristics a product and service must possess to be considered ‘environmentally friendly’ (Coggburn & Rahm, 2005). GSS also confronts the problem of the trade-off between green and other criteria, such as cost and performance (Coggburn & Rahm, 2005). Moreover, the time horizon must be taken into account when the assessment of environmental aspects typically lies further ahead (Preuss, 2005). Thus, buyers are apparently confronted with several aspects when implementing GPP.

Hence, the first research question is formulated as follows:

*RQ1. What makes GPP complex? In other words, what aspects of complexity do buyers face with GPP?*

A ‘complex system’ is defined as ‘one made up of a large number of parts that have many interactions’ (Simon, 1996, p. 183). Considering all the demands in public procurement, such as external demands, e.g. transparency and accountability, internal demands, e.g. multiple goals simultaneously and political goals, and demands on the process itself (Telgen, Harland, & Knight, 2007), and that these demands are interrelated, public procurement is complex (Amann & EBig, 2015). With a political aim for sustainable consumption and production, GPP should be implemented with accountability and transparency, and it should also follow certain processes. GPP needs to include the environmental consideration, this addition would make GPP more complex than conventional public procurement. Hence, I seek to find the kinds of challenges that buyers face with GPP.

Answering the first question will deepen the understanding of GPP’s structure and mechanisms, which leads to another question of how buyers deal with such complexity. Dealing with GPP’s complexity implies that buyers, in one way or another, consider environmental aspects in their actual operation and cognitive process. Furthermore, there might be different ways of dealing with complexity. Thus, the second research question is:

*RQ2. How are environmental considerations incorporated into the procurement*

*process?*

Lastly, answering the two questions above lays the foundation for the third question, which is concerned with the approaches or means to improve the current implementation of GPP.

*RQ3. What political and practical insights can we gain for more effective GPP, based on the current practices and issues?*

Following the discussion on the benefits of GPP described on the EU website, by 'effective GPP', the author means that: 1. The environmental impact associated with the procurement of goods and services is reduced; 2. Markets (in other words, supply chains) are led towards more environmentally-friendly technologies, products or services; and 3. Green procurement practices from the public sector are disseminated to the private sector and consumers (United Nations, 2008).

Summarising, this research aims to develop a deeper understanding of GPP and to outline directions for more effective GPP.

As mentioned above, environmental criteria play a crucial and significant role in GPP. This concerns not only the substance of environmental criteria, but also the way how environmental criteria are treated, i.e. their integration into the actual procurement process and their influence on both buyers and suppliers activities. This thesis, therefore, investigates GPP processes with a focus on environmental criteria and information related to environmental criteria.

### 1.3 Structure of this thesis

The thesis is composed of an introductory part and four papers included as appendices. The purpose of the introductory part is to synthesise the separate pieces of work and provide overall discussions as well as clarification of how they are interrelated.

The thesis is structured as follows. Chapter 1 introduces the main objectives and research questions of the thesis as well as the broad context of sustainable development and GPP's position in it. Chapter 2 provides the explanation of research context, public procurement in general and in Norway. Chapter 3 addresses how the research is positioned in the literature and provides justification of the streams of literature used in

the research. Chapter 4 provides the methodological considerations, which include the research strategy, research design and research method. Chapter 5 provides a summary of the findings in each paper. Chapter 6 presents discussions on the research questions, contributions, research limitations and future research. Chapter 7 concludes with a summary of discussions and outcomes.

Figure 1 shows an overview of the composition of the thesis. The overall research context is, in a broad sense, sustainable development, and if narrowly defined, GPP. As described earlier, there are three research questions in this thesis and multiple papers contribute to answering each question. Figure 1 also addresses the outcomes from each paper, which are bases on the overall outcome, directions for more effective GPP.

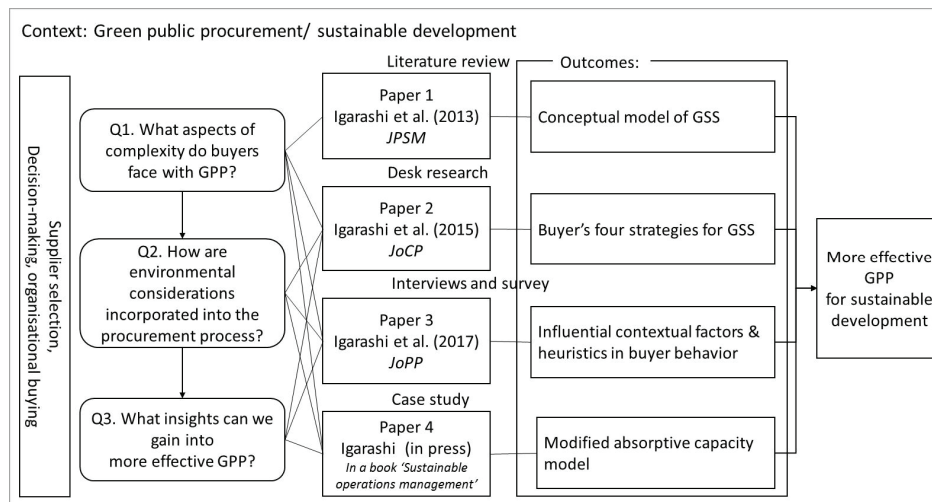


Figure 1 Structure of the thesis

## 2. Research context

The first section explicates what public procurement is, and two models of public procurement are presented. Then, the detailed processes and procedures of public procurement are described. Finally, an explanation of how green procurement works in Norway is provided.

## 2.1 Models of public procurement (definition)

Thai (2001) described public procurement as a dynamic system. His model (Figure 2) presents not only elements of public procurement based on an institutional perspective but also a ‘system in action’, which represents the conversion of inputs into outputs. Figure 2 consists of five core elements: policy making and management (Box 1); procurement regulations (Box 2); procurement authorisation and appropriations (Box 3); public procurement function in operations (Box 4); and feedback (Box 5). The ‘procurement regulations’ element (Box 2), established by policy-makers and management executives (Box 1), becomes the institutional framework within which public procurement professionals and program managers (Box 4) implement their authorised and funded procurement programs or projects (Box 3), who are also accountable to policy-makers and management executives (Box 1). The relationships between these four elements or Boxes are depicted by respective solid arrows. Finally, feedback (Box 5) will be given to policy-makers and management for possible adjustments or improvements in both Boxes 2 and 3, and to procurement professionals and managers (Box 4) for adjustments or improvements in procurement operations. This feedback relationship is shown in dotted lines in Figure 2.

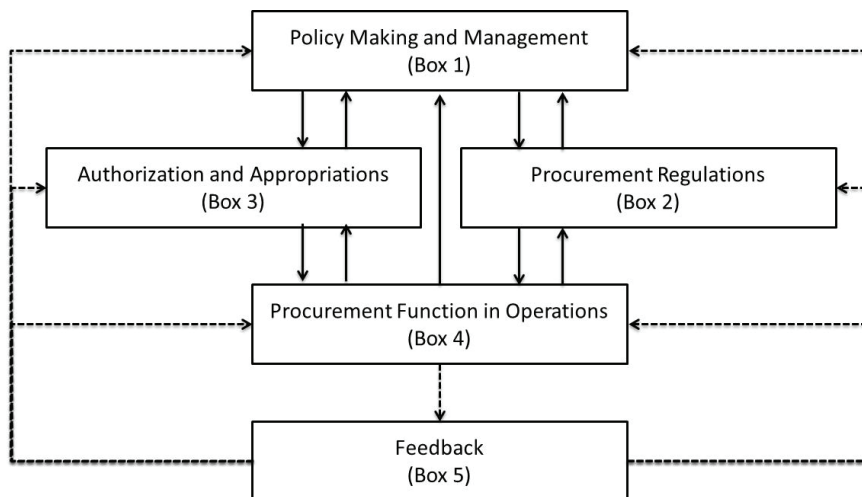


Figure 2 Public procurement system (Thai, 2001)

Prier and McCue (2009) also adopted a system perspective to conceptualise the entire

public procurement structure while acknowledging Thai's system model. Their model (Figure 3) identifies three important attributes with which public procurement can be understood. They are: 1. the legal authority for action; 2. the organisational matrix, meaning the institutional and structural environment for activities; and 3. the procurement activities. All procurement decisions are the result of a complex interaction of these three elements, which serve to structure and institutionalise the procurement process. The public procurement process begins with demands placed on the political system. The legal authority provides a basis for action by public authorities. The legal authority also prescribes how to set up the organisational matrix. The organisational matrix connects and structures the basis for pursuing the procurement action through the functional activities with the legal mandate to act (Prier & McCue, 2009). They realise the conceptual ambiguity of defining the term 'public procurement', and postulate the importance of an agreed-upon body of knowledge for practitioners, policy-makers, and academics. While developing the public procurement model, Prier and McCue provided a definition of public procurement: 'Public procurement is the designated legal authority to advise, plan, obtain, and evaluate a government's expenditures on goods and services that are used to fulfil stated objectives, obligations, and activities in pursuant of desired policy outcomes' (Prier & McCue, 2009, p. 329).

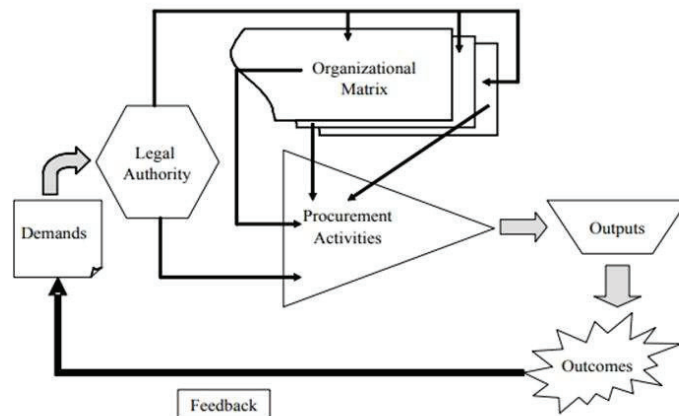


Figure 3 System perspective of public procurement (Prier & McCue, 2009)

A sound public procurement system seems to have two groups of goals:

procurement goals and non-procurement goals (Thai, 2001). The procurement goals normally include quality, timeliness, cost, minimising business, financial and technical risks and so on. The non-procurement goals concern environmental protection (promoting the use of recycled goods), social goals (assisting minority and women-owned business concerns), local business support and so on (Arrowsmith, 1998). It is very difficult for policy-makers and public procurement professionals to make an optimal decision as there can be trade-offs between these goals (Thai, 2001). GPP (or SPP) is also subject to that issue.

In contrast to private sector purchasing, the main distinctive characteristics of public procurement are the need to comply with regulations aimed at avoiding discrimination (and differential treatment) of suppliers, the principle of transparency, greater reliance on formal procedures and routine mechanisms, a focus on competitive bidding rather than negotiating, and using procurement as a tool for government policy (Arlbjørn & Freytag, 2012; New et al., 2002; Telgen et al., 2007). Thus, governments would aim for more sustainable consumption and production by setting a goal and developing policies for GPP. In procurement practices, however, public buyers are not allowed to use environmental criteria that can be regarded as favouring (or excluding) specific suppliers. The individual papers provide evidence that this is indeed one of the challenges that buyers are often faced with.

## 2.2 Public procurement process

Although public procurement can be differentiated from that in the private sector, the purchasing process or the performed activities are similar. Both public and private sector procurement starts with a buying need that has to be fulfilled, i.e. specification. Then certain activities have to be performed, either formally or informally, explicitly or implicitly, comprehensively or selectively (Caldwell, Bakker, & Read, 2007). Those activities are selection, contracting, ordering, supplier evaluation, and follow-up and procurement evaluation. The selection phase consists of supply market exploration and the selection of suppliers. This often occurs in parallel to setting the specification. The selection phase is influenced by the EU public procurement regulations. Contracts above EU threshold values should follow certain tendering procedures described in the

EU regulations. Different procedures are addressed in the next section. After a preferred bidder/s has/ve been selected, a contract is drawn up, reflecting the terms and conditions of the agreement. The buying authority must provide all bidders with details of their scores against the contract award criteria. If a tenderer is not satisfied that the award has been made properly and in accordance with the rules, they may lodge complaints to a national complaints board for public procurement (Cousins, Lamming, Lawson, & Squire, 2008). Ordering follows after the contract is made, to call off goods and services from the selected suppliers. Supplier performance is evaluated in the delivery of products. The follow-up concerns how the buying authority follows up and evaluates its activities, with a view to improving those (Caldwell et al., 2007).

### 2.3 Public procurement procedures

For the selection stage, buyers need to choose a procedure for any purchase while a buying need is identified and a specification is set. As of 2011, four procedures have been defined in the EU regulations, which are open, restricted, competitive dialogue and negotiated procedures (European Commission, 2011)<sup>1</sup>. In an open procedure, all tenderers who meet the conditions specified by the buyer will be eligible to have their tender assessed. In a restricted procedure, a minimum of five tenderers must be invited to tender by assessing their technical capacities in a prior stage. The competitive dialogue and negotiated procedures can be used in special circumstances, i.e. for purchases that require an element of adaptation of existing solutions; design or innovation; or in certain other circumstances. These procedures introduce elements of flexibility not available in the open and restricted procedures (European Commission, 2011). The focus of this study is the most dominant procedure, which is the open procedure.

Any of the procedures offer multiple stages where environmental considerations, both on the product and supplier levels, can be taken: subject matter and technical specifications; qualification criteria ('selection criteria' to use the terms of the EU); award criteria; and contract performance clause. Further explanation is provided in 2.6.

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<sup>1</sup> The new Directive (2014/24/EU) adds innovation partnership procedure.



## 2.4 Supplier selection process

Among the many activities included in procurement, such as contract management, placing orders, handling delivery, after care and supplier development (Cousins et al., 2008), supplier selection is a core activity in GPP. This is because, as described above, the basic concept of GPP relies on having clear and ambitious environmental criteria for products and services (Commission of the European Communities, 2008).

The purchasing and supply management literature describes supplier selection as a multi-stage, multi-criteria problem (Cousins et al., 2008; De Boer, Labro, & Morlacchi, 2001; see Figure 4). Whichever procurement procedure mentioned in Section 2.3 is followed, supplier selection starts with the process of identifying needs. Then, the buyers agree on measurement criteria for potential suppliers, and a call for tenders is communicated to them. Buyers make a first selection after reviewing the information submitted by candidate suppliers, usually referred to as the qualification stage. This process may take several rounds, and the final selection is made by evaluating the tenders from a limited number of qualified suppliers, based on lowest price or ‘most economically advantageous’ tender. These two options were available until 2014, when the EU changed the procurement directives. Since 2014, tenders are to be evaluated based on the most economically advantageous tender.

In addition, supplier selection may also include a post-selection evaluation of the supplier’s performance (Morton, 2002). The information obtained from a post-selection evaluation may be stored and made available for later use and improvements.

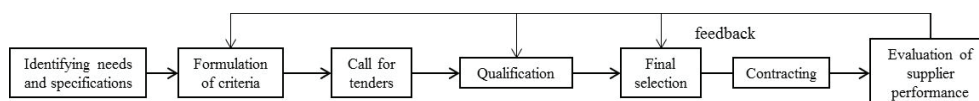


Figure 4 Supplier selection process (modified from Cousins et al., 2008; De Boer et al., 2001; Morton, 2002)

## 2.5 Framework agreement

A framework agreement may be established with one or more operators and allows for multiple contracts to be awarded without repeating the whole procurement process, in contrast to a single procurement project. Framework agreements can contribute to

GPP by allowing greater flexibility in the award of contracts, and in some cases, by pooling the demand among a number of authorities or over time (European Commission, 2011).

## 2.6 Environmental consideration in public procurement

As mentioned in 2.3, environmental considerations can be applied at different stages in the procurement process (European Commission, 2011). Technical specifications need to be related to the characteristics of the work, supply or service being purchased and not to the general capacities or qualities of the operator (European Commission, 2011). Thus, specifications may be formulated in reference to European, international or national standards. Specifications can be performance or functionality based. In the qualification stage, in order to check whether companies can perform the environmental management measures, contracting authorities may ask them to demonstrate their technical capacities to do so (European Commission, 2011). Environmental management systems such as ISO 14001 or EU Eco-Management and Audit Scheme (EMAS) can serve as a means of proof for such technical capacity. In awarding criteria, points may be allocated to recognise environmental performance beyond the minimum requirements set in the specifications. There is no set maximum on the weight you can give to environmental criteria (European Commission, 2011). Contract clauses can address environmental considerations during contract execution. The contracting authority can specify how goods are to be supplied in terms of delivery and packaging or services/works to be performed. Environmental performance may be linked to penalties or bonuses under the contract (European Commission, 2011). Table 1 presents the stages in which environmental requirements or criteria are applied and the types of requirements or criteria to be included in each stage.

Bowen, Cousins, Lamming, and Farukt (2001) differentiated between 'product-based green supply' where the focus is on the product, and 'greening the supply process' where the focus is on the behaviour of suppliers. Technical specifications and award criteria can contribute to the former 'green supply', and qualifications and the contract clause would ensure the latter 'green supply'. By addressing different types of environmental criteria at different stages in the procurement process, GPP would ensure

that both the products and services being purchased and the suppliers' supplying process will be green.

Table 1 Different environmental considerations taken in the procurement process (European Commission, 2011; Thomson & Jackson, 2007)

<b>Specification requirements</b>	<b>Qualification criteria</b>	<b>Award criteria</b>	<b>Contract clause</b>
Suppliers have to meet	Suppliers have to meet	The more points suppliers meet, the better their score is	Suppliers should follow
	Sorting	Ranking	
Product-specific criteria (including production processes and methods); management procedure-related criteria (for service)	Criteria should be related to the supplier's financial and technical ability to perform a contract; criteria can include exclusion criteria	Product-specific criteria (including production process specific criteria); management procedure related criteria (for service)	Criteria should be related to service, work, personnel, disposal and transport

## 2.7 Green public procurement (GPP) in Norway

Norway is not a member of the EU, but still follows the EU legal framework on public procurement, based on an agreement of the European Economic Area. Adopting the relevant EU directives, the Norwegian national law, the Public Procurement Act, was first published in 1992 (Norwegian title 'Lov om offentlige anskaffelser'). The Act and the appurtenant regulations have been amended according to the renewal of EU directives. The current law, Public Procurement Act (Nærings- og fiskeridepartementet /Norwegian Ministry of Trade, Industry and Fisheries, 2016), came into force on 1 January 2017, following the new EU directives: 2014/23/EU, 2014/24/EU and 2014/25/EU. In this thesis, discussions are based on the Public Procurement Act of 1999

(Nærings- og fiskeridepartementet, 1999) and its appurtenant regulations, because they were the legislations in place when most of the research was conducted between 2011 and 2015.

The Norwegian Public Procurement Act provides an important basis for environmental/sustainable related consideration as follows:

Statlige, kommunale og fylkeskommunale myndigheter og offentligrettslige organer skal under planleggingen av den enkelte anskaffelse ta hensyn til livssyklus-kostnader, universell utforming og miljømessige konsekvenser av anskaffelsen. (§6)

State, municipal and county governments and statutory bodies shall, when planning each procurement, take into account lifecycle costs, design and environmental impact of procurement.

The detailed provisions of the procurement procedures are set out in two regulations: the Regulation on Public Procurement (Norwegian Ministry of Government Administration and Reform, 2006) (FOR 2006-04-07-402), which implements the directive 2004/18/EC; and the Utility Regulation of 2006, which implements directive 2004/17/EC and is applicable to contracting entities that pursue activities in the water, energy, transport and postal services sectors. The former regulation FOR 2006-04-07-402 states in § 8-3 (1) and § 17-3 (1) that: ‘. . . the formulation of the requirements should be placed on life-cycle costs and environmental impact of the acquisition. As far as possible, concrete environmental requirements shall be imposed on the performance or function of the product.’ (Norwegian Ministry of Government Administration and Reform, 2006). Also, § 17-3 (7) and (8) articulate possible uses for detailed specifications defined in the European Ecolabel and national ecolabel. It also notes that public authorities must accept other appropriate documentation, such as technical data from the manufacturer or a test report from a recognised body.

To promote environmental and socially responsible procurement, the Norwegian Action Plan 2007–2010, which came into force on 1 January 2008, included measures for GPP implementation in the public sector (Norwegian Ministry of the Environment, Norwegian Ministry of Government Administration and Reform, & Norwegian Ministry of Child and Equality, 2007). The Agency for Public Management and eGovernment

(Difi) was established in 2008, and since then, Difi has been responsible at the national level for implementing the national action plan. Difi elaborates the methodology and guidelines as well as provides training. An example of initiatives by Difi is an environmental hub project, 'Knutepunkter (nodes)', which united a number of municipalities in counties, and passed on the necessary information and knowledge (Bergman, Ståhlberg, Dreyer, Standley, & Jonsdottir, 2012; Fet, Michelsen, & De Boer, 2011).

Public procurement in Norway is decentralised. Norwegian local authorities have a fair degree of independence when it comes to setting their own priorities and choosing how to provide services to the local community (Michelsen & de Boer, 2009). The municipalities are also free to decide to what degree environmental criteria are to be incorporated into the procurement process, as long as they comply with the Public Procurement Act.

The number of calls for tenders that include environmental requirements has been increasing in Norway, from 40% (Kippo-Edlund et al., 2005) to about 74% (Michelsen & de Boer, 2009). Norway has been one of the front runners in Europe regarding the implementation of GPP (Bouwer et al., 2005).

Norway had been collaborating with other Nordic countries through the Nordic Council, the official inter-parliamentary body, with regard to GPP for more than a decade. A process began in 2003 to develop common Nordic product-specific environmental criteria to be used in public procurement. The project resulted in the first set of criteria for eight products groups and it complements the criteria for 10 product groups by a EU project (Nissinen, Sætrang, & Ongre, 2009).

The Norden Environmental Action Plan 2009–2012 sets the objective of the Nordic region to be a pioneer in GPP (Nordic Council of Ministers, 2008). Green Growth Projects, started in 2012, involve mapping areas and product groups where existing GPP standards have proved most effective in comparison with other measures in the area. The report (Nordic Council of Ministers, 2015) states that the EU GPP criteria formed the basis of the criteria used in the Nordic countries and concludes that the Nordic region would not benefit greatly from setting up its own common criteria.

The EU has been working on publishing and revising the EU GPP criteria in about

20 product and service groups for more than a decade to facilitate the inclusion of environmental requirements in public tender documents. Core and comprehensive criteria stated in these guidelines should also lead to a more harmonised use of green criteria in procurement procedures throughout the EU.

When this research was initiated in 2011, Difi had been developing and maintaining own environmental criteria for eight product groups. However, it stopped maintaining these or developing its own new criteria, and it has been shifting towards using the EU GPP criteria or the criteria of other Nordic countries.

Thus, the context of this study, GPP in Norway, presents a common environment in terms of the overarching EU directives and EU GPP criteria with the surrounding countries. However, it should be noted that the national laws and regulations can vary between countries within a tolerable range of fulfilling the EU directives.

### **3. Positioning in the literature**

This chapter first addresses the development of public procurement research and its theoretical vigour. Next, it provides explanations of the theoretical perspectives applied in this study. Finally, the chapter also touches upon possible theoretical perspectives.

#### **3.1 Theory application in public procurement research**

Public procurement is a newly growing academic area (Matthews, 2005; Prier & McCue, 2009) that applies various disciplines or sub-fields, such as management, public administration, finance, law, supply chain and logistics management, mathematics and information technology (Flynn & Davis, 2014). Public procurement is continuing to evolve both conceptually and organisationally (Piga & Thai, 2007), yet public procurement research has involved more practitioner relevance than theoretical rigor, and researchers have been calling for more theories (Flynn & Davis, 2014; McCue & Prier, 2008). The literature review by Flynn and Davis (2014) identified an upward trend in theory use in public procurement research, but only 29% of articles had a theoretical grounding from foundational disciplines. Four disciplines were identified, namely, economics, sociology, management and psychology in order of descending frequency. Theories belonging to the micro-economics discipline have dominated, such

as principal-agent theory, transaction cost economics theory, contract theory and classic economic theory. Theories from sociology include social exchange theory, social network theory and institutional theory. Theories from management include organisational behaviour theory, organisational learning theory and the theory of lean. Theories with a psychological basis include theory of self-determination and leadership theory (Flynn & Davis, 2014). With the low grounding of theories in the public procurement literature, it is critical for this study to solidly apply a theory or theories to contribute to the existing literature.

### 3.2 The choice of theories in this study

The views on public procurement differ, and different views guide different theoretical considerations. Two views are elaborated here. One view is to look at public procurement as a decision-making process that requires, to a greater or lesser extent, optimisation/rationality under a given environment, e.g. principles and regulations of public procurement. The other view is to focus on information processing in public procurement. Other possible views are also mentioned, but they are not applied in this study.

#### 3.2.1 Public procurement as decision-making

Public buyers need to make decisions on a number of issues, such as: what to buy (identification of needs) and by when; which procedures to follow; what to demand of suppliers (qualifications) and products/services (specifications); what kinds of attributes to consider when evaluating bids (award criteria); what to mention in a contract clause, etc. When public authorities seek to implement GPP, buyers need to consider environmental aspects when making the decisions mentioned above, which is in addition to conventional procurement.

One would expect that organizations under substantial external control would be most likely to put on displays of rationality, in order to convince people/organizations who have control over them that the process is legitimate and the choice therefore is valid (Dean & Sharfman, 1993). Given this argument, some may argue that public buyers also do so, because public procurement is executed under a highly regulated

environment. However, in practice, decision-making in general occurs under time constraints, cognitive limitations, and imperfect or costly information (Simon, Thompson, & Smithburg, 1991; Simon, 1997). Buyers are also faced with limited time and resources when deciding on what to buy, searching for information on the product market to be procured and evaluating bids. Existing research has shown that buyers adapt their strategies when designing processes for procurement, e.g. how the choice takes place under complex buying situations (Barclay & Bunn, 2006; Wilson, McMurrian, & Woodside, 2001). Thus, this study will focus on how decisions are made in the procurement process in relation to the environmental consideration.

Among various decision-making theories, Steinbruner's (1976) multi-paradigmatic approach to decision-making was chosen because, rather than suggesting of one model of decision-making, it juxtaposes two different paradigms: the 'analytical paradigm' and the 'cybernetic paradigm'. It should be noted that Steinbruner's paradigm does not decouple different decision-making ways at the end of two poles, rational or irrational. Rather, it provides an account of the ways in which people structure their thoughts and process information (Caldwell, 1977).

Also, the concept of bounded rationality introduced by Simon (1947, 1957) was applied to see if buying officers' behaviours represent bounded rationality. Important elements in the bounded rationality – the human cognitive limitations and the task environment – seemed quite relevant to buying officers' behaviours in GPP, as described earlier. Further, the concept of heuristics was chosen to explain buying officers' decision-making processes because this concept concerns the process of human beings' decision-making, and it can concretise the idea of bounded rationality, e.g. how the task environment and cognitive limitation lead to a choice. There are different types of heuristics that multiple scholars suggest, such as satisfying heuristics (Simon, 1957), recognition heuristics (Goldstein & Gigerenzer, 2002) and availability heuristics (Tversky & Kahneman, 1974).

In summary, what this study focuses on is 'procedural rationality' (i.e. process of choice), rather than 'substantive rationality' (i.e. result of choice) (Simon, 1978). This study will examine how buyers search environmental criteria and how buyers frame environmental evaluation together with other categories of criteria to select a supplier.



### 3.2.2 Public procurement as information processing

Public procurement is an information intensive activity. Considering the green aspects in addition to conventional aspects of procurement means that buyers and suppliers need to process more information than they would in conventional procurement. Public buyers formulate new information into a requirement, communicate it to suppliers, and evaluate supplier's environmental information. Suppliers collect related information from contractors to formulate answers for a buyer. All of this information processing requires resources, such as time, costs and human resources. In this vein, the cost of information in GPP might be analysed using, for example, team theory (Marschak & Radner, 1972). This option was dropped, however, because the theory has little relevance to my background and because of the unavailability of scholars in my surroundings who specialised in such theory. Transaction cost theory (Williamson, 1979) was also considered as a potentially useful theory for discussing the cost of information; however, it was not considered further because an application of the theory in GPP seems tricky. One could focus on operation of environment-related information and look into production, transaction and opportunism costs.

In GPP, public organisations need to learn new knowledge related to the environmental issues in general and the specific aspects embodied in the products and services to be procured. As described earlier, public buyers transfer knowledge to suppliers as their requirements, and suppliers, in turn, give related information back to the buyers. This learning and information exchange led me to consider absorptive capacity theory (Cohen & Levinthal, 1990). Because absorptive capacity not only deals with explicit knowledge (information) but also know-how (tacit knowledge), the theory sounds even more relevant to GPP.

In summary, my practitioner-oriented background and the learning environment of my PhD study led me to apply decision-making theory and related concepts that stand at the crossroads of economics, management and psychology, and organisational learning theory, which are based in the management discipline.

### 3.2.3 Other possible theoretical perspectives

Of course, there are other potential perspectives. Public procurement occurs in contexts under various institutional influences, meaning the rules, regulations and stakeholders' values. Institutional theory explains how the institutional environment influences and establishes an organisation's structures, norms and rules, and how these become resilient, legitimatised guidelines for the organisation's behavior (DiMaggio & Powell, 1983; Meyer & Rowan, 1977; Zucker, 1987). Institutional theory is frequently used to describe how new practices are adopted in organisations (Grob & Benn, 2014). Thus, the theory sounds relevant. In borrowing institutional theory, the focus would be on public authorities' behaviour at a macro level or organizational level. However, my focus has been on revealing public authorities' or buying officers' micro behaviour, which could lead to implications at a macro level. Hence, institutional theory was considered less applicable for this study.

Another point is made by noting that implementing GPP requires individuals and organisations in the public sector to change their values, actions and routines. Hence, the theory of change management (e.g. Lewin, 1947) could be borrowed. However, this was not considered further. Change management is usually applied to deliberate change programmes, thus research drawing on change management requires data over time. What this study looks is incremental change rather than deliberate change in that it does not necessarily follow changes after a new GPP regulation or policy is introduced.

All in all, I believe that the perspectives I used fit the research focus better than other possible perspectives.

## **4. Design of the study**

In this chapter, the choice of methodologies and methods is addressed, including philosophical assumptions. According to Bryman's (2016) terminology, research strategies refer to philosophical and methodological considerations. The former includes an epistemological orientation and an ontological orientation, and the latter refers to quantitative and qualitative approaches. Research methods for data collection and analysis aim to generate evidence to answer the research questions. The first section addresses existing discussions of the interactions between philosophical considerations

and methodological practices. The next section identifies the research strategy used in the overall study. The third section provides a description of this thesis' research design. Further, the research methods of the four papers are presented, respectively. The last section provides an evaluation of the methodology based on selected criteria.

#### 4.1 Qualitative and quantitative approaches as a research strategy

It is widely held that it is helpful to distinguish between research approaches as either qualitative or quantitative, and links exist between these approaches, their philosophical orientation and worldview (Table 2). The positivistic or conventional paradigm is commonly recognised as designating the quantitative approach, while the interpretive paradigm is seen as designating the qualitative approach (Niglas, 2010). In general, the quantitative approach entails deduction of the relationship between theory and research, and the qualitative approach emphasises induction (Bryman, 2016). However, a research strategy is not necessarily linked to a single philosophical stance, nor is the distinction a hard-and-fast one (Bryman, 2016; Ridenour & Newman, 2008). In the last few decades, researchers have started to argue that quantitative and qualitative approaches are not mutually exclusive, and they have advocated the concept of a 'qualitative-quantitative continuum' (Newman & Benz, 1998; Ridenour & Newman, 2008). Instead of dichotomising quantitative and qualitative research, the qualitative-quantitative continuum relies on a concept that research may be predominantly qualitative or predominantly quantitative. Qualitative and quantitative approaches should be seen as proxies for the polar ends of a multi-dimensional continuum (Niglas, 2010). Thus, the continuum places mixed methods research in the middle, reflecting the conception that qualitative and quantitative methods should be viewed as complementary rather than rival camps (Jick, 1979).

Table 2 Common dichotomies between qualitative and quantitative approaches (modified from Bryman, 2016; Niglas, 2010)

	<b>Quantitative approach</b>	<b>Qualitative approach</b>
Role of theory	Deductive, testing of theory	Inductive, generation of theory

Epistemological orientation	Natural science model, in particular, positivism	Interpretivism
Ontological orientation	Objectivism	Constructionism
Research objective	Explanation	Understanding
	Confirmatory	Exploratory

Typically, the quantitative approach refers to research that makes use of numerical data and relies on a statistical analysis technique or mathematical modelling. In contrast, qualitative research refers to research in which arguments are not based on numbers and calculations but on the analysis of textual data (Ketokivi & Choi, 2014). Instead of focusing on the nature of the data used, Ketokivi and Choi (2014) propose that definitions should be based on the meaning of the words ‘qualitative’ and ‘quantitative’. Thus, the qualitative approach refers to one that examines concepts in terms of their meaning and interpretation in specific contexts of inquiry, and the quantitative approach refers to one that examines concepts in terms of amount, intensity or frequency (Ketokivi & Choi, 2014). I will adopt this definition in this thesis.

#### 4.2 Research strategy in this study

Decisions about the wider purpose of a research provide the framing of research questions and the research strategy (Biesta, 2010; Yin, 2009). The primary purpose of this study is to understand the phenomena and the organisational and individual buyers’ behaviours in GPP. Thus, the thesis embraces an exploratory nature as a whole, and a qualitative strategy dominates. Some of the main features of qualitative data (method) are its richness and holism, providing strong potential to reveal complexities (Miles, Huberman, & Saldana, 2014). Based on the qualitative-quantitative continuum concept, this study can be situated nearer the qualitative polar, but does not exclude the quantitative approach.

The thesis has a theoretical drive in an inductive way as a whole while the four papers have different orientations. Papers I and II use an inductive approach, developing frameworks in the end of the papers – a model of green supplier selection and the four strategies model of public buyers, respectively. Papers III and IV use a deductive

approach, drawing on behavioural decision-making theory and the absorptive capacity model. Paper III ends by shedding light on the actual presentation of elements of the behavioural decision-making theory (theory confirmation), and Paper IV expands the absorptive capacity model to the procurement context (theory elaboration). While using theory in a deductive way, the latter two papers mainly rely on a qualitative approach.

Epistemological orientation in this thesis fits interpretivism better than positivism, in which researchers share a view that people and their institutions, i.e. the subject matter of social sciences, is fundamentally different from the natural sciences. This study seeks to understand issues in GPP from the buyers' and the suppliers' points of view. It should be noted that an interpretation by a researcher provides the researcher's perceptions of the object view, and the interpretation is further interpreted in terms of the chosen theory and concepts (Bryman, 2016).

As for the ontological orientation, this thesis embraces constructionism, which asserts that social phenomena and their meanings are continually accomplished by social actors. This is in contrast with objectivism, which asserts that social phenomena and their meanings have an existence that is independent of social actors.

#### 4.3 Research design as a whole for this study

Case study is identified as the research design in this study because of the following features. The first feature is concerned with the type of research questions asked. This study has three research questions as presented in Section 1.2. RQ2 (how question) occupied a central place in this study, with RQ1 as a preparatory question for RQ2 and RQ3 as a subsequent question. According to Yin (2009), case studies are suitable for why and how research questions because these types of questions deal with operational links traced over time, rather than with frequency or incidence. The second feature is regarding the role of theory and empirical analysis. Case studies are suitable for theory building and elaboration (Stuart, 2002) and are useful where more needs to be known about a phenomenon and where existing theory seems to be inadequate (Eisenhardt, 1989). This study mainly relies on inductive approach and seeks for theory elaboration or building with the aim to obtain in-depth understanding of and insight into GPP. With these features, case study would be appropriate to the objective of the study.

Noting that this is a case study of the public procurement process in Norway, it should be added that the first research question is concerned with the complexity of GPP in general. Thus, the answers were derived from discussions in the existing literature and practices in Norwegian public procurement. Case studies do tend to use qualitative methods such as participants' observations and unstructured interviews; however, case studies can deal with a wide range of evidence, including both qualitative and quantitative evidence (Bryman, 2016; Yin, 2009). This study relies on interviews, survey questionnaires and documents. These various data collection methods allow for data triangulation so that focused aspects/phenomena are looked at from different directions and findings can be cross-checked (Yin, 2009).

In the individual papers, procurement processes in local authorities, such as municipalities and counties, and another types of public authorities (e.g. universities), are investigated as well as those of suppliers. Public procurement in Norway presents a context to the case. Norway executes its public procurement by following the EU framework for public procurement, which means Norway shares a similar legal and political background for its public procurement with the EU countries, noting that legal and political frameworks in individual countries can differ to some extent.

In the next four sections, the research design in each paper is described, respectively.

#### 4.4 Research methodology in Paper I

Reviewing the existing literature relating to a topic of interest is a crucial part in conducting research (Tranfield et al., 2003). Because selecting suppliers by considering environmental aspects is a significant process of green procurement in general, I reviewed the existing literature that explicitly focuses on green supplier selection.

I set a boundary for identifying relevant literature in terms of publication year (1991–2011), language (publication in English), and the database (Science Direct, Scopus, ProQuest ABI-inform database). The topic of focus here is GSS. Because the topic can be addressed with different wordings, I used various keywords which can replace 'green supplier selection'. Some examples are 'environmental' or 'sustainable' instead of 'green', 'vendor' for 'supplier', and 'choice' for 'selection' and so on. Analysing the literature relies on a framework that includes general categories in the literature review and idiosyncratic items specific to green supplier selection context. General categories

include year of publications, research type, and theoretical perspective. Unique categories in this literature review include the supplier selection process, supply chain position, power balance and buyer/supplier perspective, and environmental criteria.

Using these categories, the existing studies were summarized quantitatively (systematic review, Tranfield et al., 2003). Also, for some of the categories –supply chain position, power balance and buyer/supplier perspective, and environmental criteria –qualitative analysis was provided to synthesise the findings and discussions in the existing literature.

#### 4.5 Research methodology in Paper II

Utilising the unique nature of the public procurement process, that is, tender documents are accessible by everybody, Paper II examined the practice of green procurement in Norwegian public authorities by assessing tender documents. The paper analysed the environmental criteria or requirements that were stated in each item of the tender documents. The paper initially had an exploratory nature and was later developed into a theory-building study.

The data, tender documents, were extracted from the Norwegian public procurement database, DOFFIN. The database contains a set of documents in each procurement project: tender announcement, award notice document and contract clause (and, if any, attached documents). These documents state qualification requirements, specifications, award criteria, the weight assigned to each award criteria and the award result.

The existing literature demonstrates two approaches to measuring and examining the state of environmental considerations in public procurement: the use of secondary data, i.e. auditing tender documents (Kippo-Edlund et al., 2005; Nissinen, Parikka-Alhola, & Rita, 2009) and primary data gathering, i.e. conducting survey questionnaires and/or interviews (Bouwer et al., 2005; Lambert & Solevåg, 2010). While the questionnaire or interview methods possibly overstate environmental considerations because of the social desirability of the respondents, the investigation of tender documents seems to lack a reliable method of analysis, often relying on the subjective classification of the ‘greenness’ of tender documents (Prenen, 2008). Paper II aims to conquer these weaknesses, providing an objective, deep analysis of environmental criteria by auditing

tender documents.

In the collection of materials, ICT procurement projects were chosen as a focused product group because of their interesting context in GPP; that is, their potential contribution to environmental improvements, a substantial number of which addressed different environmental criteria in trans-national or national guidelines. The timeline was set in 2011; thus, only tender documents whose award notice was published in 2011 were extracted.

All environmental criteria or requirements stated in the documents were recorded in a matrix. Recorded items included the content of environmental requirements/criteria, categories of environmental requirements/criteria (product-, organisation-specific), and stages of requirements (specification, qualification, award). Procurement projects were put into four groups based on how (which category and which type) environmental requirements/criteria were used in the tender documents using the statistical technique of cluster analysis. Based on the four emerging groups, buyers' strategies of including or not including environmental criteria in tender documents were derived. Thus, I claim that I used both quantitative and qualitative analysis in the paper.

#### 4.6 Research methodology in Paper III

Both qualitative and quantitative approaches were employed in Paper III. Because the aim of the study was to investigate a phenomenon about which little has been known, i.e. buying officers' behaviour in considering environmental criteria, applying an interview technique and obtaining deep and detailed data as a first step seemed appropriate. Then, a survey questionnaire was developed using phrases identified in the interview data, because one of the questions was to examine factors that could affect a buying officer's environmental behaviour. This way of combining qualitative and quantitative research is called 'instrument development' mixed research (Bryman, 2006).

This paper had a deductive theoretical drive. The assumption was that the buying officer's behaviour is, to a great or small extent, driven by bounded rationality and/or heuristics. Especially, task characteristics may influence how buying officers seek related information when considering environmental criteria for supplier selection.



Based on both interviews and survey questionnaires, the study confirmed the explanatory power of the concepts of bounded rationality and heuristics in the GPP context.

#### 4.7 Research methodology in Paper IV

The subject of Paper IV, information exchange between buyers and suppliers, is an overlooked theme in public procurement. The paper employed a deductive case study (Barratt, Choi, & Li, 2011), with an embedded multiple-case design (Yin, 2009). In the case study, buyers and suppliers from three product groups were interviewed to collect in-depth statements and viewpoints from both sides. The three product groups were information and communication technology (ICT), consumer suppliers and office suppliers. These were selected because they were expected to exemplify common situations and issues in GPP, and they are goods that are typically procured by public authorities. Furthermore, the selected product groups are covered by GPP criteria guidelines issued by the EU and individual nations. This implied that these product groups would have well-recognised environmental issues to deal with in the supply chain, and providers and customers are more or less aware of such environmental issues. Hence, it was potentially expected to identify critical and interesting decision-making issues in procurement processes in these groups. The interviewed public authorities were approached by convenience sampling and some were by snowball strategy. Public buyers made suggestions about suppliers to be interviewed. The sampling strategy here was not a main concern since the case studies were being used to confirm or falsify a theory; what was more important was the contextual data (Barratt et al., 2011).

While the main data collection method was interview, supplementary information was gathered from procurement tender documents.

The constructs looked at in the data were built on concepts of absorptive capacity. Data were first analysed in a single case (a product category) by process coding and evaluating coding (Miles et al., 2014) and then analysed in cross cases. The latter analysis highlighted issues appearing in multiple cases.

Table 3 provides an overview of material used in each paper.

Table 3 Material used in the individual papers

	<b>Data collection methods</b>	<b>Data</b>	<b>Focus</b>
Paper I	Literature search	60 articles	Existing findings
Paper II	Desk search	46 sets of tender documents	Call-for-tenders stage
Paper III	Interviews	Three interviews in different public authorities	Buying officers' thought processes in the stage of selecting environmental criteria
	Survey	62 respondents (Response rates in two different groups: about 10 % and about 28%)	
Paper IV	Interviews	11 interviews (seven interviews in three buyer organisations, four interviews in four supplier organisations)	Information exchange between the buyers and the suppliers and information processing at both actors

#### 4.8 Methodological evaluations

Traditionally, the criteria for quantitative research are validity, reliability, replicability and generalisability (Bryman, Becker, & Sempik, 2008). Some qualitative researchers adopt criteria originating from quantitative research, while others argue that criteria originating from quantitative research are not appropriate for qualitative research, depending on their paradigms. Lincoln and Guba (1985) proposed alternative terms for assessing qualitative research. Trustworthiness, an umbrella word for evaluating criteria of a qualitative study, includes four aspects – credibility, transferability, dependability and confirmability. These are in parallel with a part of quantitative research criteria, namely validity and reliability. Further, researchers have discussed evaluation criteria for research that combines elements of qualitative and

quantitative research for the last decade (Bryman et al., 2008; Creswell, 2013); still, there is no consensus on a set of criteria for a mixed method.

This study includes both qualitative and quantitative research at the level of data collection and analysis; thus, the criteria for mixed method research could be adopted. However, I chose to use criteria for qualitative research to evaluate this study as a whole for several reasons; there is a lack of widely accepted criteria for mixed method research; the qualitative approach is dominant in this study; and I am standing on an interpretive paradigm. Table 4 indicates various measures taken to ensure the methodological rigor of this study.

There are research limitations stemming from the research methodologies used in this study. They will be addressed in Chapter 6.

Table 4 Trustworthiness evaluation of the thesis

Criteria	Definition (Bryman, 2008; Lincoln and Guba, 1985)	Measures taken in this study
Credibility	<ul style="list-style-type: none"> <li>- Whether there is a correspondence between researchers' observations and the theoretical ideas they develop.</li> <li>- If research is carried out according to the principles of good practices.</li> </ul>	<ul style="list-style-type: none"> <li>- Through iterative processes between theoretical foundations and data interpretations, there would be more sound relationship between the data and theory.</li> <li>- Data triangulation (Jick, 1979) utilising various data sources, such as interviews, tender documents, and organisations' websites.</li> <li>- Interview data were recorded and transcribed. The interviewees were asked to confirm the summary of interviews. Also drafts of papers were sent to interviewees to confirm that the interpretations were correct.</li> </ul>
Transferability	<ul style="list-style-type: none"> <li>- Whether findings hold in some other contexts, or even in the same context at some other time.</li> <li>- If a thick description of qualitative research provides others with a database for making judgements about the</li> </ul>	<ul style="list-style-type: none"> <li>- The cases and research context were described in detail so that others could see the similarities of their findings by comparing contexts.</li> </ul>

	possible transferability of findings to other milieu.	
Dependability	<ul style="list-style-type: none"> <li>- If the research keeps an audit trail (complete records are kept in all phases of the research process in an accessible manner).</li> <li>- If there is more than one observer.</li> <li>- Whether other research peers agree about what they see and hear.</li> </ul>	<ul style="list-style-type: none"> <li>- It is not always possible to have complete records of research processes because of iterative processes of theory and data considerations. Notes about ideas and thoughts were written down. Research meeting minutes were also kept.</li> <li>- There was usually more than one researcher engaged in data collection and analysis in each paper (multiple investigators, Barratt et al, 2011; Eisenhardt, 1989).</li> <li>- There were discussions with the supervisors and colleagues as needed. Earlier versions of every paper were presented at conferences and got feedback from researchers in the same field.</li> </ul>
Confirmability	<ul style="list-style-type: none"> <li>- Researcher should not overtly allow personal values or theoretical inclinations to sway the conduct of the research and the findings derived from it.</li> </ul>	<ul style="list-style-type: none"> <li>- Discussions with the supervisors, colleagues, and researchers with different theoretical backgrounds, would help mitigate the author's personal values or vested interest in certain theories.</li> </ul>

## **5. Summary of findings**

In this chapter, brief summaries of the findings in the four papers are provided. Information about the four papers is given in the list of papers on page 8.

### **5.1 Paper I: What is required for greener supplier selection? A literature review and conceptual model development**

The paper reveals several characteristics of existing studies on GSS. First, GSS research has just started to attract the attention of scholars. Second, mathematical research that looks into the supplier selection model is the most dominant after conceptual research about developing conceptual frameworks for integrating environmental aspects into supplier selection. Third, research based on empirical data is less prevalent. Fourth, the private sector is typically more frequently targeted than the public sector. Last, much of the research lacks a clear theoretical background.

Weak areas identified from the literature review are that the earlier stages of supplier selection have been given little attention, such as the need-identification stage and formulating the criteria stage, in spite of their significance on the quality of later stages. The dyadic perspective of GSS is lacking. Regarding the research type, there is a need for empirical research with an analytical conceptual framework.

Narrative analysis of the literature and identification of these characteristics leads us to suggest a GSS model that illustrates four key dimensions of GSS. The first dimension concerns the alignment of the supplier selection strategy with the organisation's overall environmental strategy. It is necessary for firms to have a clear vision of what 'green' means to them and to have an understanding of aspects that are important to the purchasing function according to the vision. Only then would environmental criteria be ready to formulate with meaningful phrasing for inclusion in a purchasing decision. The second dimension concerns some forms of decision support tools. The third dimension, which is also closely related to the alignment of strategies, addresses interrelated decision processes in GSS. There is always a question of where in the multiple supplier selection stages environmental criteria should be concretised. It makes a difference to both buyer and supplier organisations if environmental criteria are used as screening criteria (qualification, specification) and/or ranking criteria (award criteria). Multiple criteria in different stages of supplier selection should present a coherent set aligned

with purchasing and which further the organisation's overall strategy.

Regarding the fourth and final dimension, we argue that it is important to consider the supply chain context. GSS can be more effective when buying authorities are aware of their limitations and possibilities based on their supply chain position and the power balance between suppliers. Viewing supplier selection as an inter-organisational issue, more focus will be put on the communication of environmental criteria between buyer and supplier organisations and further understanding by supplier organisations.

We further argue that the four dimensions are interrelated to each other with the first dimension, the alignment of the overall green strategy with the purchasing strategy, in the centre. Changes or decisions in one dimension are likely to have consequences for the other dimensions.

Based on the result, the paper suggests future directions of research into GSS and implications for buyers and policy-makers.

## 5.2 Paper II: Investigating the anatomy of supplier selection in green public procurement

The analysis of tender documents shows that inclusion of environmental criteria varies among procurement projects in terms of the amount of and places for environmental criteria. Cluster analysis of patterns of inclusion of environmental criteria produces four groups. The first group has environmental criteria in specification. The second group does not state any environmental criteria. The third group has environmental criteria in qualification, and some also have specification. The fourth group includes environmental criteria in award criteria as well as other stages. Apart from these four groups, we identified a group where statements could implicitly indicate environmental criteria even though they are not necessarily addressed under a label of environment.

Applying Steinbruner's behavioural decision-making theory to these findings, we argue that buyers basically use four approaches to deal with green supplier selection, i.e. how to concretise environmental considerations in the supplier selection process. The four approaches we propose are *ignore*, *incorporate*, *insist* and *integrate*. We define *ignore* approach as when buyers follow conventional supplier selection criteria and do

not put environmental criteria into tender documents. A cybernetic paradigm (Steinbruner, 1976) could explain that actual pressure on addressing environmental aspects is low and there is no need to make any changes in existing standard procedures of supplier selection. The *incorporate* approach refers to cases in which environmental criteria are added to existing criteria, such as quality or service. Buyers need to make minor changes or adjustments in the current decision-making process. This again presents a cybernetic paradigm rather than an analytic paradigm, because changes are made locally, and the decision-making process remains more or less the same by embedding environmental criteria in another existing criterion. The environmental aspect is not independently traded-off against other aspects. The *insist* approach concerns cases in which environmental criteria function as qualifiers in the specification and/or qualification stages; thus, buyers accept only suppliers who exceed a minimum requirement of environmental criteria (and other criteria). Changes in the supplier selection procedure are bigger than the previous two cases in that explicit, independent environmental criteria are added. However, because environmental criteria are absent in the award stage, a trade-off between the environment and other performances does not occur. Thus, a cybernetic paradigm fits better with this approach. In the last group, *integrate*, environmental criteria are applied in the award stage, which means that environmental performance is traded-off against performance in other areas, such as cost and quality. The extent of the trade-off depends on the weight given to environmental award criteria and is not always an effective degree. Therefore, the *integrate* approach exemplifies the analytical paradigm because buyers need to integrate performance value in different criteria. It should be noted that three out of the four approaches, i.e. except the *ignore* approach, are used in combination.

In addition to the above main findings, an assessment of tender documents also demonstrates that holding an environmental management system is remarkably dominant in qualification criteria. In award criteria, environmental criteria are used most frequently after price and quality, but the average weight given to environmental criteria is lowest among others, including delivery, service, cost and so on. This means environmental criteria often has little influence on suppliers' final evaluation.

Altogether, it is too early to say whether environmental considerations and an



effective use of environmental criteria penetrate public procurement. We identified contradictions in policy recommendations and practices.

### 5.3 Paper III: Analyzing buyer behavior when selecting green criteria in public procurement

This paper explores buying officers' behaviour in identifying or formulating environmental criteria to be used in supplier selection. The study first identifies where and how buying officers search for information when considering environmental criteria to be stated in a tender document. It is found that there are different types of information-seeking attempts and actions among buying officers, which are termed 'operational procedures'. Their belief that one can contribute to environmental issues through his/her occupation as a buyer seems to be a significant role when considering environmental criteria. Further, 'recognition', 'availability', 'imitation', and 'satisficing' heuristics are emerging in various operational procedures. Another finding is that buying officers process only a part of the information available or use only a part of the information sources available. They seem to be exposed to more information than they can handle.

Second, contextual factors that could affect a buying officer's environmental behaviour are examined. The contextual factors include buyer characteristics (gender, occupational position, experience as a buying officer), organisational characteristics (organisational size) and procurement project characteristics (product category, number of offers). The analysis revealed that buying officers in higher positions tend to search for information more actively, and especially from external sources, which in this study included information from the market, other authorities and legal documents. Another significant relationship is between the organisational size and the buying officer's behaviour. Buying officers working in larger organisations use internal information sources more than smaller organisations. This is because internal sources in larger organisations are developed to a level that buying officers can use. Some differences in buying officers' operational procedures depend on whether a buying officer conducts goods procurement or services procurement. The different nature of a procurement project is likely to affect their behaviour.

The paper provides the first attempt to acquire insights into the impact of procurements' context and to understand and interpret buying officers' behaviour more deeply and in more detail than found in the existing research.

#### 5.4 Paper IV: Information exchange and processing in buyers and suppliers in green public procurement: An absorptive capacity perspective

The paper applies an absorptive capacity view on information exchange and processing in the interactions between buyers and suppliers. The key concepts in absorptive capacity used in this study are the five capabilities composing absorptive capacity as defined by Todorova and Durisin (2007): recognition of the value; acquisition; assimilation; transformation; and exploitation.

Different opportunities exist for buyers and suppliers to communicate environmental information and share related, necessary information. Such opportunities include a dialogue conference, market investigation, tender documents, evaluation of tenders and follow-up meetings. The study identified the abovementioned five capabilities working during information exchanges and processing in these opportunities.

The study found the need for buyers to strengthen their assimilation/transformation and exploitation capabilities when formulating environmental criteria that are legally stated and which contain an appropriate level of requirements according to the market. Acquisition capabilities seem to differ among buyers, with different ways of collecting possibly relevant information and knowledge.

Evaluating suppliers' environmental performance is an issue that probably attracts the most attention from both buyers and suppliers. Buyers display a lack of confidence or competence about evaluating suppliers' performance. To cover this lack of competence, buyers could ask for advice from external experts or even avoid the use of environmental award criteria. There are some questions thrown up by suppliers as to whether buyers actually evaluate the environmental information from suppliers (transformation), and if buyers understand the documentation submitted by suppliers (assimilation). It was also pointed out by suppliers that environmental issues are not followed up in the contract period (exploitation). With regard to this issue, buyers need to further develop assimilation, transformation and exploitation capabilities.

The issue does not only reside in the buyer's process, but also in the supplier's process of formulating answers. Suppliers acknowledge that compiling information from the supply chains is possible, but challenging. Buyers sometimes receive excessive documentation from suppliers, which turns out to be unrelated to environmental requirements in the end. Thus, suppliers may not know what to focus on in their answers.

Based on the findings, the paper further argues that effective GPP outcomes would be obtained when both the buyers' and the suppliers' absorptive capacities reach a level whereby the two actors can deal with and respond appropriately to necessary environment-related information. This argument could further explain why some organizations are better in implementing GPP.

The study provides a unique examination of buyers' and suppliers' interactions regarding information exchange and use, complementing the existing procurement literature, which predominantly focuses on the buyer's perspective and points out suppliers as one of the barriers to green procurement. The paper suggests the possibility to better utilize suppliers' competence.

## 6. Discussion

This chapter synthesises and elaborates the findings from the four independent papers to answer the three research questions. The chapter is composed of three sections, which correspond to the research questions in Section 1.2, and contributions, research limitations, and future research.

### 6.1 What makes GPP complex?

The first research question can be rephrased as ‘*What aspects of complexity do buyers face with GPP?*’ Paper I identifies what characterises GSS based on existing research. Together with the findings from the other three papers, this section discusses the aspects of GPP complexity from two levels: the strategic and the operational levels. Table 5 shows the aspects of complexity that each paper addresses.

Table 5 Aspects of GPP complexity addressed in each paper

	Strategic level		Operational level				
	Alignment	External context	Preparation of tender document phase			Tender evaluation phase	
			What (Which of)	How	Where	Tool	Scoring
Paper I	O	O	O		O	O	
Paper II			O	O	O		
Paper III	(O)	(O)	O	O	O		
Paper IV	O	O			O		O

#### 6.1.1 The strategic level

Most importantly, the purchasing function needs to be strategically aligned with the organisation’s overall green strategy, as the literature review identified. The importance of strategic alignment echoes Cousins et al.’s (2008) supply model, which has strategic

alignment in the centre of the wheel with the other five elements surrounding it. Paper I argues that without such an alignment, buyers cannot define the focused area of green or a strategic priority. Defining a focused area leads to the next step of deriving meaningful environmental criteria in procurement projects, which goes into the operational level.

The external context also has a significant meaning in GPP strategy and implementation. The external context can include legal pressure, stakeholders, relationships between buyers and suppliers and so on. One organisation in Paper IV exemplifies how the organisation is concerned about relevant regulations and is in fear of violating laws. According to the European Commission (2011), 'to get a more detailed picture from the market you can also engage in dialogue with potential suppliers prior to tendering' (p. 18). Thus, a dialogue with suppliers is allowed during the preparation phase, as long as the process is carried out in a transparent and non-discriminatory manner. Unfortunately, multiple organisations do not understand this.

While studies typically view green purchasing as an internal activity of the buying organisation, Paper IV suggests that a GPP outcome cannot be expected without balanced capabilities of both buyers and suppliers in sending and receiving environment-related information and processing information internally. In relation to this, if a supplier perceives that a buyer superficially deals with environmental issues in a procurement project and in general, i.e. in their organisational strategy, the supplier would not put value on a sincere response to environmental requirements. It is not only the development and management of buyer's internal processes that make GPP challenging, but also the management of interrelationships.

#### 6.1.2 The operational level

The complexity of GPP resides both in the preparation of tender documents phase and in the evaluation of tender phase. The preparation phase has multiple complexity aspects.

Paper II demonstrates that including environmental criteria in the procurement process is not straightforward. The first issue is which concrete environmental criteria should be chosen among the wide variety of possible criteria. A list of possible

environmental criteria can be long-winded. Buyers need to be able to identify which one(s) are most relevant and significant in a project they are faced with. Once buyers identify the environmental criteria, the level of environmental criteria is questioned as to whether it is described in a graded quantity. An example would be if the energy use of a desktop computer is below 60W when in active use, if it has more than a four-year warranty and a service agreement, etc. Directive 2004/18/EU states that technical specifications should not create unjustified obstacles to the opening up to competition (European Commission, 2011). Interviews with suppliers indicate that they are sensitive if a criterion is too strict for the current technical level in the market. As Paper IV addresses, buyers are also quite concerned about the appropriate level

The next issue is how environmental requirements can be presented. Buyers need to decide if they want to incorporate environmental criteria into existing criteria, such as quality, or if they have a new, independent label for environmental requirements. While the former does not require buyers to change the conventional supplier selection procedure so much, the latter urges buyers to integrate the value of the environmental performance of suppliers with other performance. In relation to this, here is another issue: where in the multiple stages of the supplier selection should environmental criteria be included. They can be in specification, qualification and/or award criteria. Each stage has a different nature and role: while specification and qualification serve as mandatory requirements, award criteria are used for ranking. While specification and award criteria should be product-specific, qualification should be organisation-related. Putting environmental criteria in the right place looks like a demanding job.

Lastly, there is a technical issue in the selection and evaluation process. Paper I witnessed a large number of studies focused on mathematical or technical models in the area of green supplier selection. De Boer et al. (2001) identified such trends in supplier selection literature in general. Existing research (e.g. Kaufmann, Kreft, Ehrgott, & Reimann, 2012) has shown the potential of such models to produce higher quality outcomes. This implies that some tools assisting decision-making in supplier selection could be helpful for buying authorities. However, even with such tools which help structure different criteria and calculate a total score, reading and understanding information on environmental performance that suppliers submit has to be done by

human beings, i.e. procurement officers. As the interviewees in Paper IV indicated, a challenge for buying officers is to judge if a supplier's performance meets the requirements they set or score the level of the supplier's environmental performance. Environmental criteria are often not ones whereby suppliers can answer yes or no. In addition, environmental criteria are difficult to measure in the delivery phase of a product or service and even in usage. These aspects add a new layer of complexity.

## 6.2 How are environmental considerations incorporated in the procurement process?

This question focuses on how buyers incorporate (or do not incorporate) environmental considerations in the procurement process when dealing with the complexity of GPP identified above, strategically and operationally.

### 6.2.1 How are environmental criteria incorporated strategically?

The author's papers argue little about the practices of alignment of the overall and the purchasing strategies. Still, data collected for Papers III and IV reveal different situations among organisations. One informant sees no clear connection between the overall environmental strategy and the procurement one, while another states that the description of the procurement strategy on the environmental issues is too general to have implications on practical operations. These are examples of organisations in which the buying officers do not see the procurement function positioned in the overall organisational strategy. In contrast, one buying authority explicitly addressed the specific aim of the environmental area in its procurement strategy in relation to the organisation's strategy. That public authority had been a leading actor in GPP and recognised by some suppliers. The authority had experienced a hard time at the beginning, receiving complaints from suppliers when it became an active green pathfinder a decade ago. The authority is still an active leader in GPP, initiating cooperative purchasing with its neighbouring local authorities. Cooperative purchasing is 'the cooperation between two or more organisations in a purchasing group in one or more steps of the purchasing process by sharing and/or bundling their purchasing volumes, information, and/or resources' (Schotanus & Telgen, 2007, p. 53). This could be a powerful measure of diffusing green procurement practices.

When it comes to the external context, organisations choose whether to utilise an external knowledge base on GPP, specifically when selecting environmental criteria and evaluating the environmental performance of suppliers. Such an external knowledge base includes ecolabel organisations and the EU's standardised environmental criteria. By borrowing knowledge or competence required for GPP from outside the organisations, they implement GPP without obtaining resources with such competence within the organisations.

The legal dimension of public procurement could allow public authorities to take an inactive approach in GPP, as observed in Paper IV. Buying authorities tend to look for what is restricted in public procurement laws and regulations, rather than what opportunities are available in relation to environmental considerations.

#### 6.2.2 How are environmental criteria incorporated, operationally?

Where in the procurement process environmental considerations can be taken would be the first issue buyers need to face, together with the aspect of which environmental criteria. Environmental considerations can be set in multiple stages of the procurement process, i.e. specification, qualification, award and contract stages. Environmental criteria in the specification and qualification are mandatory, and only bidders who meet those requirements (both at the product/service level and the organisational level) qualify for further consideration. Paper II found that approximately 70% of the projects have mandatory environmental criteria in any form, but only less than 20% of the projects have both specification and qualification. Environmental award criteria are used to grade their bidders and are not mandatory. According to Paper II, about 36% of the projects include environmental award criteria. Interviews in Papers III and IV identified that non-confidence in grading environmental performance prevents buyers from actively using environmental criteria in the award stage. This may explain the low number of award criteria applications in Paper II. The contract clause is an alternative place to address environmental considerations. Buyers can ensure the supplier's environmental performance by following up on the description in the contract clause during the contract period. However, an interviewee in Paper IV testified that environmental aspects are never followed up.



In parallel with considering the where dimension, which environmental aspects to treat in the procurement process is questioned. Paper II presents a list of environmental criteria used in ICT procurements. The list includes as many as 31 product-related criteria and eight organisation-related criteria. When buyers search for potential environmental criteria and consider which one(s) should be ultimately applied in a current procurement project, they tend to use a part of the information sources available (Paper III). Their behaviour is associated with some types of heuristics in behavioural decision-making literature; buyers refer to environmental criteria from a familiar situation or follow what they are used to doing (recognition heuristics). Buyers also use easily retrievable information (availability heuristics), and copy environmental criteria that other authorities have (imitation heuristics). Thus, the way of searching for potential environmental criteria to use depends on simplifying approach rather than analytical, comprehensive or rational approaches.

How environmental requirements are presented in relation to existing criteria such as quality or service are treated in two ways; they are either embedded in existing criteria or they have a new 'environment' category or something similar. Paper II found that buyers sometimes try to stay with minimal, local adjustments. An interviewee in Paper III suggested including environmental criteria within other criteria could be more integrated with the product's attributes, rather than having environmental criteria as an independent category, depending on the procurement projects and the kinds of attributes. Paper II observed that most projects categorise environmental criteria in an independent category. In those cases, buyers need to have additional work for environmental criteria, often involving a trade-off with other criteria, and this requires much more work than a local adjustment (Paper II).

Given how and where dimensions are addressed, setting independent environmental criteria in the final selection stage, i.e. as award criteria, seems to require extra effort and work on the buyers' part, because they need to aggregate scores for environmental and other performance, such as cost and quality. In Paper II, about one-third of procurement projects implemented this practice. The weight given to the environmental award criteria varied, from 5% to 20%. The environmental performance score, however, would not influence the final result, i.e. which supplier/service would be awarded, if the

weight given to the environmental criteria is low. It remains unanswered whether those projects that include environmental criteria in the award stage actually result in selecting different products, as opposed to when the procurement is conducted without environmental award criteria. As mentioned earlier, this study did not focus on the final result; instead, the focus was on process of tender document development. In spite of this issue, environmental criteria can, whatever their weight, raise awareness for environmental impacts of a particular product/service (Kippo-Edlund et al., 2005).

To cope with the operational complexity, EU and national GPP criteria should be greatly helpful for buyers. The EU instructions and national criteria standardise which environmental aspects should be included and where, and the numerical values of the requirements. It also includes information on verification methods. Paper II witnessed that in practice EU and national criteria are often included in tender documents, supporting that such standardised criteria are useful and easy to apply. While standardised GPP criteria help buyers cope with GPP complexities and promote the inclusion of environmental criteria, and thus could be quite influential on GPP implementation, it should be noted that there is a risk of blindly applying criteria without actually understanding. This issue is captured by a statement from a supplier in Paper IV who doubted whether buyers actually know what they are asking. There is another risk, lock-in, regarding standardisation (Rainville, 2017). Standardised criteria need to be maintained and up-to-date to avoid such risk. Indeed, the EU works hard to update and revise its GPP criteria.

As addressed earlier, the complexity of GPP not only resides in the preparation of tender documents stage, but also in the evaluation of tender stage. Paper IV revealed that buyers often have difficulties evaluating suppliers' documentation on environmental performance, especially when they need to assess information from suppliers (sometimes from sub-suppliers) that does not follow standard product descriptions. One solution for this challenging issue is to make use of competence from an external expert organisation. In this way, buyers can secure their evaluation of the environmental performance of suppliers while simultaneously saving time and human resources. The interviews in Paper IV indicated that both buyers and suppliers welcome more diffusion of the standards of information or product descriptions in the environmental information

exchange between buyers and suppliers, e.g. more use of eco-labels as environmental performance information.

Finally, how buyers incorporate environmental consideration in terms of decision-making rationality is addressed. In general, human beings' judgement as to whether a decision is rational or not hinges on what values we apply when evaluating it (Simon et al., 1991). Considering what is expected in GPP (see p. 12, definition of GPP), being rational in the GPP context would mean that buyers make decisions while seeking to minimise damage to the environment and maximising benefits to the buying authorities and society. Following this, the way of taking the most rational account of environmental value would be to first screen potential suppliers according to mandatory environmental requirements and then evaluate the selected suppliers based on award criteria that include independent environmental criteria. However, what was evidenced in Paper II is that buyers tend to simplify the structure of environmental performance evaluation by including only mandatory environmental requirements or by incorporating environmental criteria into a conventional criterion. Such buyers' behaviour may be considered a rational option as long as organisational resources (e.g. time and manpower, to tender process done) are highly valued, however, decision-making in GPP appear to present bounded rationality after all.

6.3 What political and practical insights can we have into more effective GPP, based on the current practices and issues?

This question concerns implications for policy-makers and practitioners. They will be addressed in separate sections here. Implications for researchers will be described later in a section concerning future research.

#### 6.3.1 Implications for policy-makers

There are mainly three points and the first point contains multiple suggestions. First, this study implies that policy-makers should take buyers' behavioural aspects, i.e. inclination to avoid structural changes in the procurement process, into consideration when they make policies. The current political approach does not seem effective given that political recommendations are not often followed. While 20% is suggested by Difi

(2008) as the minimum weight for environmental award criteria and 10%–15% by the EU (European Commission, 2011), only half of the projects that had environmental award criteria fulfilled this. Difi guidelines further explicitly state that environmental criteria should not be concealed as a part of other criteria. While it would be easier for supervising organisations of public procurement to monitor the inclusion of environmental criteria that are addressed as an independent category, it seems simpler for both buyers and suppliers to treat environmental criteria within an existing category. This is because only a minor adjustment is required in the operational process, and sometimes it can be only natural to include environmental attributes to other variables, such as quality or service. Policy-makers should acknowledge that having independent environmental criteria with a weight of 10%–20% requires complex information processing on the part of the buyers, because the value of environmental performance has to be aggregated into other performance. If policy-makers would like to go further in this direction (weight and independent category), they should put more pressure on the public sector to invoke a public authorities' reaction, and at the same time, they must provide buyers with opportunities to develop their competence to handle this complex GPP, including learning capabilities of environmental aspects and technical capabilities to include environmental criteria in the procurement process.

Maybe one suggestion could be that treating environmental criteria as an independent category might not need to be stressed. Rather, enhancing buyers' understanding of environmental aspects in relation to an existing category, e.g. quality/energy use, delivery, durability, would help buyers (especially those who are not so competent or ready for GPP) include environmental considerations in procurement projects. This seems adverse to the current direction of GPP, but it makes sense to suppose that it might be more effective in procurement projects where environmental aspects are connected to existing categories, given the absorptive capacity concept and cognitive demands. Learning new knowledge is much easier if you can associate it with existing knowledge (Cohen & Levinthal, 1990). Fewer adjustments in the decision-making process are required to extend existing knowledge and incorporate the new knowledge into it, than to treat new knowledge as completely new information.

Also, it would be helpful if policy-makers and supporting organisations provided a

platform for buyers to learn know-how, e.g. how to find out the technical environmental aspects of products and services in general. The role of different types of environmental requirements (specification, award criteria, etc.) and their consequence on the outcomes need to be correctly understood by buyers, too. Policy-makers need to provide such tacit knowledge.

Currently, policy-makers put their efforts into providing explicit knowledge by standardising GPP criteria. Standard criteria could be helpful for buyers to identify criteria and for suppliers to expect criteria, as well as make communication between buyers and suppliers easier. As addressed in 6.2.2, such standard criteria entail the risk of lock-in. Standard criteria should be updated in a way that buyers raise the level of environmental criteria over time, which would in turn enhance market improvements in environmental performance. An environmental performance level that is set at a certain time cannot work as a qualifier or ranking criteria forever. Environmental (and sustainable) issues require endless effort, both incrementally and innovatively. An environmental goal is often not something that can be achieved at a certain level. In order to stimulate continuous improvements, the numerical values of environmental criteria should be flexibly revised.

In short, policy-makers and policy-implementation organisations should seek effective instructions by taking buyers' behavioural issues, i.e. inertia, cognitive limitations, into consideration.

Second, creating a platform for sharing experiences of green procurement could be meaningful. Certainly, there have already been some networks and initiatives in the EU; however, their main focus was typically on sharing 'best' practices or successful project cases. I would like to seek attention here on sharing and discussing cases of misusing environmental criteria or using outdated environmental criteria. Paper II observed some cases in which environmental criteria are misused and Paper III pointed out that there is a risk of dissemination of an incorrect usage of environmental criteria due to imitation heuristics. Learning from failure is an essential step for success (Edmondson, 2011), thus sharing failure and understanding what are wrong is important in GPP.

Third, policy-makers could seek putting more emphasis on utilization of suppliers' competence. Paper IV indicated that suppliers get demotivated because of their

perception about how buyers treat their information on environmental criteria. Paper IV further implies that there is some room to make better use of suppliers' potential as a driving force on GPP. Presenting opportunities for communication between public authorities and suppliers would help. Policy-makers should listen to suppliers and derive policies that involve suppliers in public procurement to a greater extent.

### 6.3.2 Implications for practitioners

First, an implication at the management level regards human resource management. This study and existing research (Grandia et al., 2015) suggest that buyers' individual values about environmental/sustainable issues can affect the environmental considerations in procurement, whereas experience as a buyer does not affect his/her thinking process in searching environmental criteria. Having a person who strongly values environmental/sustainable issues would help organisations enhance green procurement. Of course, the organisation must have a clear procurement strategy that aligns with the organisational strategy. With these two (a person and a strategy), GPP will be promoted substantially. While the skills needed for procurement projects will be acquired through training and experience, personal values about the environment/sustainability would not be obtained easily in the short term. Thus, it is recommended that human resource management should prioritise persons who value environmental issues.

Second, buyers should be aware of the aspects of GPP complexity as well as the human nature of decision-making, less analytical or rational, and cognitive limitations. To make the most use of the procurement process, it is important for buying authorities to understand that environmental requirements are imposed on suppliers with two different functions – mandatory criteria (specification and qualification) and scoring criteria (award). The contents of environmental criteria can differ, too. Qualification criteria should be organisational specific. Specification and award criteria need to be product/service specific. To cope with the complexity stemmed from different roles of environmental requirements, green procurement beginners could use only the mandatory criteria as a starting point. The cognitive burden is much lighter compared to having award criteria, still, minimum environmental performance is secured. However,

in this case, the buyer would fail to reward for better environmental performance (Parikka-Alhola & Nissinen, 2012). Then, advanced and experienced public authorities should set environmental award criteria in addition to specification and qualification. The award criteria need not be complicated, and it is better to focus exclusively on the most important environmental aspects in a given procurement to reduce complicated evaluations. Substantial weight should be given to environmental award criteria. In this way, the final selected supplier (or product) presents lower environmental impacts. Suppliers who work hard on developing environmentally friendly products or services can get paid and, further, be more motivated. Put another way, buyers can be attractive to suppliers.

Placing environmental requirements in different stages without truly understanding the different roles does not make sense. It can make the selection process more cumbersome both for buyers and suppliers. If buying authorities do not possess the competence to evaluate suppliers' bidding documents, and just state environmental criteria here and there in tender documents to make themselves look like green procurers, suppliers will know how serious the buying authorities are about environmental issues. Paper IV found that the suppliers often see the buyers' environmental criteria as rhetorical to meet the regulations. Here is the third implication. Buying authorities should be responsible for what they require in the tender documents. They should be more sensitive to how suppliers perceive their attitude about environmental issues. Further, if buying authorities pay more attention to suppliers' willingness to contribute to environmental issues, it is possible to bring out suppliers' potential on GPP. Having communication with suppliers at procurement stages where communication is legally accepted would be useful.

Fourth, buyers should acknowledge that buying officers tend to use some heuristics when searching related information for environmental criteria, and in most cases, unconsciously. Applying heuristics may be a fast way of reaching environmental criteria, but there is a question if it produces the most effective choice.

Fifth, this research revealed that GPP requires buying authorities to have different kinds of capabilities, including the acquisition of new knowledge, assimilation, transformation and exploitation. It is too demanding for individual buyers to have all

these capabilities, but because the buying authority or procurement team is composed of multiple persons, it would be possible to acquire these capabilities as a whole organisation or an entire team.

#### 6.4 Contributions

First, the study demonstrated that behavioural decision-making theory and information processing theory play significant roles in advancing our knowledge of GPP. The public procurement research stream is especially weak in theoretical rigour, with only 29% (of the articles published between 2001 and 2013) having a theoretical grounding (Flynn & Davis, 2014) compared to 67% (of the articles published between 2001 and 2010) in supply chain management (Carter & Easton, 2011). The combination of decision-making theory and information processing (or more broadly, organisational learning) theory makes this research novel. There is a good reason for the combination; decision-making is all about how people collect relevant information, process information and structure their thoughts.

Second, the study contributes to extending the application of absorptive capacity, which has been typically adopted in the R&D business setting, to the public procurement setting. This could further imply another possibility of applying absorptive capacity to understand the B-to-B buyer-supplier setting.

Third, earlier research on GPP in Norway found that 70%–80% of procurement projects are ‘green’, meaning that the projects with the percentage include environmental criteria. It appears to be a good implementation rate in reference to the percentage in EU member states (CEPS & College of Europe, 2012), but the study revealed that including environmental criteria is not a straightforward job for buyers. There are so many aspects for buyers to deal with, including strategic level considerations, technical aspects in the procurement process, and information processing capabilities, etc. We should not judge if GPP is going well simply by looking at the frequency of ‘green’ projects. It can be one of the parameters of GPP; however, I would argue that the frequency figure is too superficial. One knows little or almost nothing behind the figure. This study filled this gap that exists in earlier research, and revealed the reality by investigating buyers’ decision-making in practice in the



procurement process.

Fourth, the policy-makers are informed about recommendations based on the investigation of green procurement practices at the very micro operational level from a behavioural perspective. Such an insight into environmental policy has been pointed out as lacking (Gsottbauer & van den Bergh, 2011).

### 6.5 Research limitations

This section will address the research limitations stemming from the research methodologies used in this study.

First, the possibility of generalisation is an issue traditionally addressed in case study research (Eisenhardt & Graebner, 2007; Yin, 2009). Recently, Dubois and Gadde (2002, 2014) pointed out that case studies cannot build on statistical inference. Instead, they have to rely on analytical inference. The main mission of case study researchers is not to achieve generalisation, but rather, to strive to illustrate the case they have studied properly in a way that captures its unique features (Ruddin, 2006). Logical coherence as a foundation for analytical generalisation is an important criterion for case research (Dubois & Gadde, 2002). This study is produced by 'back and forth processes between theoretical framework, data sources, and analysis' (Dubois & Gadde, 2002, p. 556), through which the logical coherence of this study is believed to be refined.

Next limitations are related to the research scope. Claiming that this is a case study of Norwegian public procurement processes, the processes were chosen from specific product groups that excluded services. This may limit the findings; still, the author believes that the findings of this study will at least hint at service procurement, because the fundamental approach and concept of GPP is common for product and service procurements. Another condition for the scope is that the study focuses on procurements above the threshold value defined by the EU directive. Procurements under the threshold value neither need to be published in the EU database, nor follow the EU rules, but follow national level rules. Such rules are normally less strict and more open to individual judgements of the persons involved (Michelsen & de Boer, 2009). Unfortunately, this study does not investigate procurements under the threshold. Both the financial impact and the environmental impact from the above-threshold

procurements will be greater. That is why this study focuses on procurements with larger values.

Third, this study investigated how procurement is done, with the focus on environmental decision-making in different organisations in the Norwegian public sector, by looking at procurement projects executed between 2011 and 2015. The data collected in this study concerns a certain time period because the development of green procurement implementation is not the intention of the study. Thus, this study does not entail longitudinal data.

Further, a limitation related to the choice of theoretical perspectives should be addressed. This study applied theories that look at both individual and organisational levels. Whereas Steinbruner's decision-making paradigms, Simon's bounded rationality and heuristics account for individual decision-making behaviour, absorptive capacity is concerned with organisational learning. My account is that searching alternatives for a facing problem needs to be done by individuals (searching possible environmental criteria). In this stage, the concepts of bounded rationality and heuristics are applied. Through intertwining processes between different individuals' decision-making, an organisation reaches the environmental criteria stated in the tender documents, which can be seen as a result of organisational decision-making. Steinbruner's paradigms are applied in such a stage. Communication during the procurement processes is done by the two organisations – buyers and suppliers. This is where absorptive capacity is applied. The nature of the processes which was focused on in this study supports the mixed level in the theoretical perspective.

Lastly, research limitations related to the researcher's ability are mentioned. While adopting different research designs in the individual papers adds a unique characteristic to the study, it is difficult for a researcher to accumulate experience and acquire expertise in one data collection or analysis method. If needed, an expert in a specific research method was invited to join the study. The researcher's main supervisor was always there to assist methodologically or theoretically. The author could obtain a wide range of experience in different methods through the whole study; thus, the research process was learning by doing.

## 6.6 Future research

Following the previous section on limitations, directions for future research are outlined.

First, future research is welcome to investigate GPP from the perspectives of decision-making and information processing in other countries in the EU and expand the discussions in this study, by highlighting the differences and commonalities in different countries.

Second, longitudinal research would deepen the body of knowledge in GPP by studying how the implementation of GPP has been/is developed or changed with policies updated at the super-national and national levels. Murray (2009) points out that the voices of politicians, major stakeholders in public procurement, have been largely overlooked in public procurement research. Through the development of legal regulations and establishing its precise content, the influence of politicians on public procurement has been and is pervasive (Murray, 2009). In addition to the political influence, demands from other stakeholders can influence GPP (Kamann, 2007). Future research should explore the transition of GPP and what triggers change in GPP implementation, for example, with a view of change management.

Third, the application of absorptive capacity theory suggests a possible view that GPP is a process of supplier and buyer relationships, not a process of merely buyers' procurement activities. According to the propositions by Dyer and Singh (1998) regarding safeguarding length and relational rents, suppliers in public procurement only feel secure for the contract period, and it would be difficult to create a collaborative landscape in which buyers and suppliers are willing to exchange information or knowledge. Still, Paper IV demonstrated evidence that both sides wish for a mutually rewarding relationship. Existing studies highlight the importance of collaborative relationships between public buyers and businesses (Arbjørn & Freytag, 2012; Bovaird, 2006; Erridge & McIlroy, 2002). Future research should contribute to developing the understanding of potential collaborative relationships in public procurement.

Fourth, because GPP is often said to be a driver for eco-innovation, providing industry with incentives for developing environmentally friendly products, services and works (OECD, 2013), contribution of GPP on innovation could be investigated. From

the innovation viewpoint, public procurement can be categorised into three types: procurement for radical innovation; procurement for incremental innovation; and ‘off-the-shelf’ procurement (Rainville, 2017). Radical innovations are products or services with characteristics that surpass those currently on the market, thus requiring pre-commercial procurement, which is a process of R&D (Commission of the European Communities, 2007). Incremental innovations integrate, customise and adapt existing solutions to meet user needs. In off-the-shelf procurement, buyers select products and services already on the market (Rainville, 2017). The projects researched in this study seem to deal with off-the-self innovation procurement and incremental innovations. This study witnessed that standardized criteria such as EU criteria and eco-labels are often referred in the procurement process. Such standards support GPP by increasing the availability and stringency of environmental criteria and holding markets to higher standards (Commission of the European Communities, 2008). However, in cases of using these criteria, the role of public authorities would be to adopt emerging or developed innovations (Rolfstam, Phillips, & Bakker, 2011) and less likely to trigger innovations (Uyarra, Edler, Garcia-Estevez, Georghiou, & Yeow, 2014). Furthermore, standards can encompass the risk of lock-in and buyers need to consider the long-term innovation impact of the standards (Rainville, 2017). Contribution of GPP on eco-innovation could be further sought.

Lastly, I believe that this research would be beneficial to research in socially responsible public procurement. In other words, it should be possible to investigate the integration of social criteria in public procurement in a similar way. In addition, findings regarding the integration of environmental and social criteria in the public procurement process will together contribute to deepening the knowledge in sustainable public procurement.

## **7. Conclusions**

This thesis investigated GPP, how it works and how it is implemented, by analysing decision-making and information processing in relation to environmental criteria at individual and organisational levels. The research was a case study of procurement processes in the Norwegian public sector and consisted of four papers, including a

literature review.

Most importantly, this thesis questioned the existing notion of GPP that inclusion of environmental criteria is core and can be a measure of GPP (Amann et al., 2014; Bouwer et al., 2005; Commission of the European Communities, 2008; Testa, Grappio, Gusmerotti, Iraldo, & Frey, 2015). The study's findings emphasize that it is not enough for the public sector to just include environmental criteria in tender documents in pursuit of its effect on sustainable production and consumption. The role in the selection process that environmental criteria have, the contents of environmental criteria, and how information on environmental criteria from suppliers is used by buyers do matter. Buyers need to have right knowledge and know-how on these aspects to implement effective GPP.

The study identified various key dimensions for effective GPP: 1. Buyer's capabilities on formulation of tender documents; 2. Buyer's and supplier's capabilities on information processing; and 3. The external context dimension.

The first dimension mainly concerns the aspects of GPP complexity on the operational level; buyers need to identify environmental criteria to be ultimately chosen for a particular project (what), to decide how environmental criteria are presented in tender documents (under an independent category or an existing category) (how), and to consider multiple stages where environmental criteria are included (where). To handle these, buyers need to identify necessary information, to possess technical knowledge of environmental aspects in products/services, and to be familiar with the public procurement process. The current practices investigated in this study indicate that the buying officers are inclined to choose a short-cut solution or a good-enough solution when they are searching for information. That is, buying officers appear to be bounded rationally. In formulating tender documents, they need to consider where and how aspects. The study found that the buying officers are inclined to avoid the changes needed in the procurement process for GPP from conventional ways. They present cybernetic decision-making rather than analytical decision-making. Notably, this thesis does not argue that one buying officer should possess all capabilities to handle these aspects of GPP complexity, but a buying authority can build a procurement project team with each member possessing different capabilities and complementing each other. This

could not be realised without organisational strategic management, such as the provision of training and a clear procurement strategy, as well as policy support with clear instructions.

The second dimension includes both buyer's and supplier's capabilities to process information, transform habits, and communicate with the other actor. One of the interesting findings is that the suppliers often saw the buyers' environmental criteria as rhetorical to make the project look green. Actually the buyers were not confident in evaluating information on suppliers' performance regarding environmental criteria. Such suppliers' doubts could lead to negative feedback about their learning about environmental issues in the future as well as their future response to environmental requirements. How information of environmental criteria is processed is critical. Further, the thesis argues that both buyer's and supplier's organisational capabilities on information processing together determine the outcomes of GPP. In other words, GPP can evolve through buyers' and suppliers' activities in conjunction. Buyers and suppliers need to identify weak capabilities and develop them, while policy-makers should facilitate buyer-supplier interactions.

Third, the external context mainly entails political support. Currently in public procurement, there seems to be tension between policy and practices. Regulations and recommendations neither seem to be powerful enough to invoke reaction to the public sector broadly, nor to be distant in buyers' decision-making. Interpretations of regulations can vary, and some cases saw that buyers were prevented from actively including environmental criteria due to the fear of violating regulations. The study indicates that standardising GPP criteria would help both buyers and suppliers cope with GPP complexity. Importantly, policies should have a system that can continuously stimulates both the consumption and production sides to improve environmental performance to avoid the lock-in risk, as well as provide fundamental knowledge and know-how on GPP to help buyers deal with GPP.

The study is unique, theoretically and methodologically. It draws on individual behavioural decision-making literature and organisational learning literature. The methodologies employed include both qualitative and quantitative approaches.

Research that points the way towards a sustainable society has emerged in the last

decades, and it is characterised by its transdisciplinary approaches (Kates et al., 2001; Komiyama & Takeuchi, 2006). I hope this research will have further meaningful implications for 'our common future' when combined with other research in sustainable development.

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## **Appendices**

### **Paper I**

Igarashi, M., de Boer, L., & Fet, A. M. (2013). What is required for greener supplier selection? A literature review and conceptual model development, *Journal of Purchasing and Supply Management*, 19(4), 247–263.

### **Paper II**

Igarashi, M., de Boer, L., & Michelsen, O. (2015). Investigating the anatomy of supplier selection in green public procurement, *Journal of Cleaner Production*, 108, Part A, 442–450.

### **Paper III**

Igarashi, M., de Boer, L., & Pfuhl, G. (2017). Analyzing buyer behavior when selecting green criteria in public procurement, *Journal of Public Procurement*, 17(2), 141–176.

### **Paper IV**

Igarashi, M. (in press) Information exchange and processing in buyers and suppliers in green public procurement: An absorptive capacity perspective. In L. de Boer and P. Andersen (eds.), *Operations Management and Sustainability*. Palgrave Macmillan

Paper I





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## What is required for greener supplier selection? A literature review and conceptual model development



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## ABSTRACT

This paper examines the existing literature on green supplier selection. In total, 60 articles are reviewed, all published in peer-reviewed journals between 1991 and 2011. The articles are analyzed in terms of several general variables such as type of research and theoretical viewpoint, as well as more specific variables such as the supply chain position considered, stages of the supplier selection process studied, and the perspective taken on environmental criteria. The main findings are threefold. First, analytical research, focusing on developing normative decision models for the final stage in green supplier selection is clearly most dominant, employing a wide range of techniques. Second, empirical research is less prominent and generally lacks a clear theoretical background. Third, very little conceptual research has been done linking green supplier selection to an organization's strategy. Research on green supplier selection is highly fragmented and in danger of overemphasizing the technical aspects of supplier selection. Based on this review of the articles, a conceptual model of green supplier selection is presented, aimed at integrating the different dimensions of green supplier selection and identifying directions for future research.

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### 1. Introduction

Over the last two decades, environmental considerations have become a significant issue in purchasing (Deans, 1999; Min and Galle, 1997; Preuss, 2005). Today, both the public and private sector face increasing pressure to consider the environmental aspects in their purchasing policies from a growing number of government regulations, stakeholders and NGOs. This consideration of the environmental aspects is recognized as green purchasing or green procurement. As a result of green purchasing, companies and industries, which provide environmentally friendly products and services, can receive more recognition for their efforts. More firms are then likely to be motivated to design, produce and provide environmentally friendly products and services. Thus, the green market expands, and green purchasing is regarded as a contribution to sustainable development. The first green purchasing initiatives appeared during the 1980s and 1990s (Dowlatshahi, 2000).

Green purchasing has significant implications for the firms implementing it, especially when it comes to the criteria used in supplier selection. Until the early 1990s, purchasing policies, supplier selection and evaluation processes were dominated by

criteria such as price, quality and delivery (Weber et al., 1991; Dowlatshahi, 2000). Green purchasing, however, requires the inclusion of environmental criteria in supplier selection, which leads us to the concept of green supplier selection (GSS) (Lamming and Hampson, 1996; Noci, 1997). By "green" we refer to the environmental aspects within the sustainability concept. It should be noted that the environmental aspect is often mentioned as one of the three aspects of sustainability, the others being social and economic aspects (Elkington, 1998).

Selecting a supplier can be regarded as an important decision, not only in the sense of providing the purchasing organisation with the right materials, products or solutions at a competitive cost level, but also in the sense of improving its environmental performance, e.g., through avoiding hazardous materials or considering alternative solutions that require less materials and/or energy. A firm's environmental efforts will not likely succeed without integrating the company's environmental goals with its purchasing activities (Walton et al., 1998). However, GSS is often far from straightforward. There are multiple environmental criteria one could include, and the operationalization of these criteria into meaningful, practical and measurable variables often poses challenges, both for purchasers and suppliers (Jabbour and Jabbour, 2009; Lloyd, 1994).

The existing literature on supplier selection is quite extensive, and much attention has been paid to what kind of mathematical models can be used for supporting decision-making (De Boer et al.,

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2001; Wu and Barnes, 2011) and what kind of criteria are used in supplier selection (Stamm and Golhar, 1993; Weber et al., 1991). Neither the review of decision models for supplier selection by De Boer et al. (2001) nor a follow up study by Wu and Barnes (2011) explicitly addresses green supplier selection. Furthermore, previous studies by Weber et al. (1991) and Stamm and Golhar (1993) do not report any environmental criteria. There is, therefore, a clear need to assess and review the literature on GSS. Providing a comprehensive review on GSS is the first major contribution of this paper. In addition, based on the review, we develop a conceptual model of GSS, aimed at integrating its key dimensions. This is the second important contribution of the paper.

Noteworthy literature reviews addressing the environment or sustainability in related but broader fields, have been recently published; Giunipero et al. (2012), Hoejmose and Adrien-Kirby (2012), and Miemczyk et al. (2012) in purchasing and supply management, Carter and Easton (2011) and Seuring and Müller (2008) in supply chain management. They look at the broader field, excluding both the studies of mathematically conceptualized models and the public sectors (with the exception of Hoejmose and Adrien-Kirby in the latter case). In contrast, this review includes literature on GSS comprehensively, focusing more specifically on the selection process rather than the purchasing function or supply chain management in general. Furthermore, it should be clearly noted that this paper does not focus on decision models for GSS per se, but includes all the literature which discusses environmental aspects in supplier selection. In this sense, the scope of this review is broader than the reviews by De Boer et al. (2001) and Wu and Barnes (2011) who focused specifically on decision models.

This paper aims to answer the following questions: “What characterizes the existing studies on green supplier selection?”, “What are the unaddressed or overlooked areas within green supplier selection research?” and “What could be the future directions of research into green supplier selection?” This paper provides an overview of the existing articles on GSS, demonstrates useful categorizations for analyzing these articles, and proposes a conceptual model that can be used for researchers and practitioners in the field of GSS. Thus, we aim to assist both researchers and practitioners.

The organization of the paper is as follows. First, we provide definitions of three key terms. Second, the methodology for the literature review is presented, as well as the framework for analyzing the articles. Then, we present the analysis of the articles found. Next, based on the analysis of those articles, a conceptual model for GSS is suggested. The paper ends with a conclusion regarding the characteristics of the literature on GSS, unaddressed aspects, potential further research, and implications for researchers, practitioners and policy-makers.

## 2. Definition of key terms

### 2.1. Definition of green purchasing

The concept of green purchasing has obtained a place in the field of supply chain management and various definitions of green purchasing have been developed. One of them is:

...green purchasing is an environmentally-conscious purchasing practice that reduces sources of waste and promotes recycling

and reclamation of purchased materials without adversely affecting performance requirements of such material (Min and Galle, 2001, p. 1223).

Another definition, using a term “environmental purchasing”, also emphasizes the efficient use of materials and reduction of overall consumption:

...environmental purchasing is defined as purchasing's involvement in supply chain management activities in order to facilitate recycling, reuse and resource reduction (Carter and Carter, 1998, p. 660).

Zsidisin and Siferd (2001) have pointed out that a weakness of the Carters' definition is that it provides a view of environmental issues solely from a purchasing perspective, and, furthermore, that it does not capture the holistic and synergistic impacts that intra- and inter-organizational practices have on the natural environment. They offer an extended definition as follows:

Environmental purchasing for an individual firm is the set of purchasing policies held, actions taken, and relationships formed in response to concerns associated with the natural environment. These concerns relate to the acquisition of raw materials, including supplier selection, evaluation and development; suppliers' operations; in-bound distribution; packaging; recycling; reuse; resource reduction; and final disposal of the firm's products (Zsidisin and Siferd, 2001, p. 69).

We will follow the definition by Zsidisin and Siferd (2001) since this definition recognizes the potential environmental impact caused in the relationship between suppliers and purchasers, and, in addition, explicitly mentions the involvement of supplier selection and evaluation in green purchasing.

### 2.2. Definition of the supplier selection process

Supplier selection is usually referred to as one activity, yet comprises several tasks (Cousins et al., 2008; De Boer et al., 2001; Van Weele, 2010), as illustrated in Fig. 1. It typically starts with the process of identifying needs. Then, purchasers agree on measurement criteria for potential suppliers, and a call for tenders is communicated to potential suppliers. A selection is made after reviewing the information submitted by candidate suppliers. This usually takes several rounds, and the final choice is made from a number of qualified suppliers. In addition, it may also include a post-selection evaluation of the supplier's performance (Morton, 2002). The information obtained from a post-selection evaluation may be stored and made available for later use and improvement. The evaluation of supplier performance is sometimes also referred to as “monitoring suppliers” (Zhu and Geng, 2001) or “application feedback” (Wu and Barnes, 2011). By including post-selection evaluation in our model of supplier selection, we extend previous models of the supplier selection process (De Boer et al., 2001; Wu and Barnes, 2011) without changing their core structure.

### 2.3. Viewpoints on environmental criteria

It is generally recognized that a wide range of environmental criteria are used to measure environmental impact. They are applied in the supplier selection process, in addition to the conventional criteria such as price, quality, and delivery. Environmental criteria are

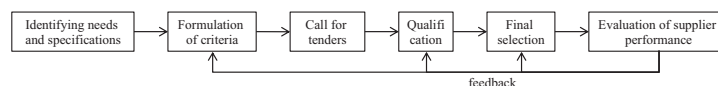


Fig. 1. Supplier selection process (Cousins et al., 2008; De Boer et al., 2001; Van Weele, 2010).

commonly structured in relation to either the product or service being purchased or to the supplier producing or providing them (Pettersen and Larsen, 2011; Fet et al., 2011).

In this study, we apply the classifications 'product-related criteria' and 'organization-related criteria' as the main point of departure, thereby following the established terminology, most notably in the public sector and EU-policy documents.

### 3. Methodology

According to Webster and Watson (2002) the importance of a literature review lies in creating a firm foundation for advancing knowledge and facilitating theory development. Certain areas of research may be closed and new areas may be discovered. To provide a comprehensive review of GSS, we clearly and precisely define the literature to be targeted.

A three-stage process was used for our review, modified from methods employed by Tranfield et al. (2003) and Seuring and Müller (2008):

1. Material collection: the material to be collected is defined and delimited.
2. Category selection: general aspects, e.g., publication year, research type, etc., and specific aspects of the material to be assessed are selected.
3. Material classification and evaluation: the material is analyzed according to the categories defined in stage 2.

Stages 1 and 2 are described in Sections 3.1 and 3.2, respectively. Stage 3 is described in Section 4.

#### 3.1. Material collection

In order to extract articles which deal with GSS, a structured keyword search was conducted in two resources: three databases and 10 selected journals. The two-pronged search method is depicted in Fig. 2.

The left side in Fig. 2 shows the search in three major databases, Science Direct (which contains 2500 peer-reviewed journals), Scopus (which contains 18,000 peer-reviewed journals), and ProQuest ABI-Inform database (which is widely recognized in the Economics and Business Administration area, and contains 3000 periodicals).

Regarding key words, we used various alternatives of "green supplier selection" from the purchasing literature. "Green" was replaced by either "environmental" or by "sustainable". We reasoned that "environmental" often has the same meaning as "green" in the sense of a reduced impact on nature, "sustainable" embraces the three aspects: economic, environmental and social, and is thus a broader term. "Vendor", "contractor" and "partner" were used interchangeably with "supplier". For the concept "selection", the alternatives were "choice", "evaluation", "assessment" and "qualification". In total, we had 60 combinations of key words which were used for searching the entire texts in articles. Examples of our search terms included "green vendor selection", "environmental supplier evaluation" or "sustainable supplier assessment". We also searched by multiple keywords, such as "green" AND "supplier selection", "environment\*" AND "supplier evaluation", or "sustainable\*" AND "supplier assessment" in the title and abstract. As commonly known, "\*" indicates a wild card search. We used "\*" for "environmental" and "sustainable", because these words also appear in forms such as "environmentally friendly", "environmental soundness", "sustainability" or "sustainably" depending on their grammatical usage.

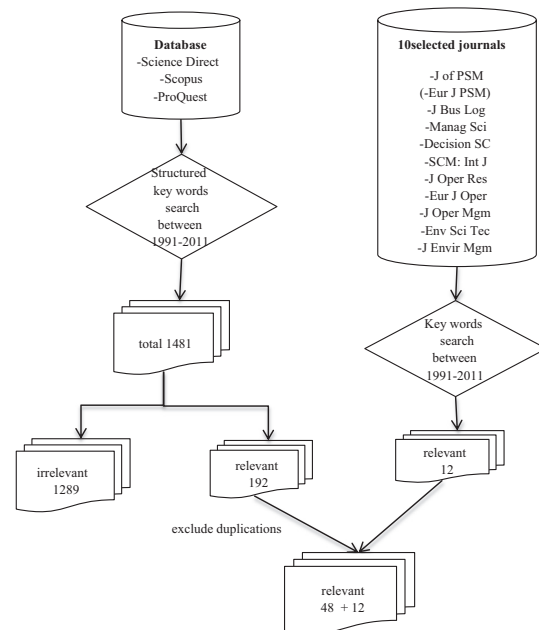


Fig. 2. Material collection method flow.

Since "GSS" is a decision-making process in green purchasing, we also searched by multiple word phrases such as "green purchasing" AND "decision making" in the title and abstract. "Purchasing" and "procurement" were used interchangeably. Although the difference between the terms "purchasing" and "procurement" is discussed by researchers, there are no common differentiations (Cousins et al., 2008; Van Weele, 2010). While some say "procurement" is the more strategic of the two and "purchasing" covers the day-to-day activity, others say the reverse (Cousins et al., 2008). We followed the usual custom of using "purchasing" and "procurement" interchangeably, and used both for searching articles. "Green" was again replaced by "environmental" and "sustainable". Hence, we had six combinations of words instead of just "green purchasing".

In the search flow illustrated on the right side in Fig. 2, we searched in 10 selected journals in the areas of general management, purchasing management and environmental management. All these journals have received an Impact Factor rating higher than 1.0 by Thomas Reuters in the recent past. We also used a journal list which was reviewed by Weber et al. (1991) as a reference. We searched these journals separately because some of them were not included in the databases for all of the years where articles could be published. The 10 selected journals were: Journal of Purchasing and Supply Management (before 1995), European Journal of Purchasing and Supply Management, Journal of Business Logistics, Management Science, Decision Sciences, Supply Chain Management: An International Journal, Journal of the Operational Research Society, European Journal of Operation Research, Journal of Operations Management, Environmental Science & Technology, and Journal of Environmental Management.

This systematic search should ensure that we accumulated a relatively complete census of the relevant literature (Webster and Watson, 2002).

The search was restricted to articles published in scholarly and peer reviewed journals, written in English and published between 1991 and 2011. In 1991, Weber et al. published their seminal article

on supplier selection criteria (Weber et al., 1991), where they reported no environmental criteria among supplier selection articles until 1990. Hence, 1991 seemed to be a logical starting point for mapping any publications on green supplier selection.

We obtained a total of approximately 1500 articles as initial candidates from our database search. After judging whether each article dealt with a specific issue related to green supplier selection or evaluation by its title, abstract, or text, a total of 192 articles were chosen. If an article did not mention the green aspects in supplier selection, the article was excluded even though it contained key search words such as “environment” and/or “supplier selection”. After eliminating the duplicates, 48 articles were chosen as literature to be reviewed from the database search. The duplications resulted from the fact that the same article appeared for different key word searches. 12 additional articles were retrieved from the 10 journals described above. In total, we obtained 60 articles for a full paper review.

### 3.2. Category selection

We used the following general classification categories for the review of the relevant literature: year of publication, research type, and theoretical perspective. In addition to these general categories, we developed a more specific classification scheme for reviewing the articles on GSS, based on the supply chain position and the stage in the supplier selection process. The different perspectives on environmental criteria were also key categories for classification. The classification categories are listed in Table 1, and a further explanation of each category is given in the following sub-sections.

#### 3.2.1. Year of publication

As explained in Section 3.1, the search was limited to the period from 1991 to 2011. Each of the 60 articles was classified according to its year of publication.

#### 3.2.2. Research type

The classification of the articles in terms of research type is based on Wacker (1998). He divides theory-building research into

two groups: analytical and empirical research. Analytical research, which uses deductive methods to arrive at conclusions, is further classified into three sub-groups: analytical conceptual research, analytical mathematical research, and analytical statistical research. Analytical conceptual research includes the development of concepts and conceptual modelling. Analytical mathematical research is used to develop new mathematical relationships between variables, and to study how the models behave. Analytical statistical research integrates logical/mathematical models from analytical research and statistical models from empirical research into a single theory. The models are developed for future empirical statistical tests.

Empirical research is classified into three sub-groups: empirical experimental research, empirical statistical research, and empirical case study. Empirical experimental research involves examining relationships between variables by manipulating these in a controlled setting to determine the exact effect on specific dependent variables. In empirical statistical research, quantitative empirical data from a large number of organizations are analysed. Empirical case studies seek to develop insightful relationships between variables through in-depth observations of real world processes, usually within a limited number of organizations.

#### 3.2.3. Theoretical perspective

For each article, we look at the presence of specific theories. Given the topic, one could assume that theories such as transaction cost economics, agency theory, and resource-based view are used in the papers on GSS. On the other hand, a recent review on the topic of purchasing and supply chain management (Chicksand et al., 2012) suggests that much of the research in this field lacks a theoretical basis.

#### 3.2.4. Supply chain context

First, our definition of “supply chain context” includes three elements: the supply chain position, the power balance between buyers and suppliers, and the inter-organizational perspective taken in the study.

The relative position in the supply chain considered by each article is an important characteristic in our review. Depending on

**Table 1**  
Classification categories in the review.

Categories	Attributes, notes
Year of publication	1991–2011
Research type	– Analytical (conceptual, mathematical, statistical) – Empirical (experimental, statistical, case study)
Theoretical perspective	Theory addressed in an article
Supply chain context	– A first tier supplier or a sub-system provider as a supplier and an end-product manufacturer, a construction company, a service provider as a purchaser, or more upstream relation
– Supply chain position	– An end-product manufacturer, a construction company, a service provider as a supplier and an end-user (a government agency, a municipality or a private sector user) as a purchaser
– Power balance	Whether an article addresses relative power balance between the focal buyer and its suppliers
– Perspective	Only the buyer's perspective is taken into account or both the buyer's and the supplier's perspectives are taken into account
Supplier selection process	– Identifying needs and specifications – Formulation of criteria – Call for tenders – Qualification – Final selection – Evaluation of supplier performance
Environmental criteria	– Product-related criteria – Organization-related criteria

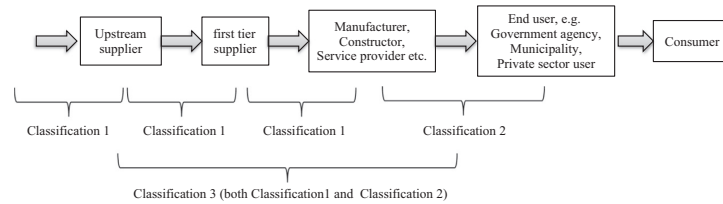


Fig. 3. Classifications of possible supply chain positions in the review.

which position the focal supply chain actor has, the environmental impact of supplier selection may be different, especially from a life cycle perspective, and furthermore, external pressure on environmental issues varies. Detecting a supply chain position for all articles will enable us to derive implications for future research. Supplier selections occur in different supply chain positions involving different adjacent actors. We use three classifications: (1) The buyer is an end-product manufacturer, a construction company, a service provider or a more upstream organization such as a parts manufacturer or a sub-system provider. (2) The buyer is an end-user such as a government agency, a municipality or a private sector user (excluding the personal consumer). (3) The positions in classification 1 and 2 are considered simultaneously in the paper. The classifications are displayed in Fig. 3. For each article we identified whether the research focused on specific positions in the supply chain, and if so, what these positions were. Where a description was not clear enough to detect the supply chain position, or no descriptions were given, we classified the supply chain position of the paper as 'not specified'.

The second element of supply chain context concerns the relative power of the buyer over suppliers and vice versa. We will assess whether or not the papers address this issue.

Regarding the last element of supply chain context in supplier selection, we will assess whether a study takes the perspective of only one side (e.g., the buyer's perspective), or both sides, i.e., including both the buyer's and supplier's perspective.

### 3.2.5. Supplier selection process

In Section 2.2, we presented a general supplier selection process model (see Fig. 1). The different stages in a supplier selection process have their specific features (see De Boer et al., 2001) and therefore it is important to consider which stage(s) is or are covered in each article on GSS. For each article we assessed which of the following stages were addressed: identifying the needs and specifications, formulating and weighing the criteria, the call for tenders, the qualification of suitable suppliers, the final selection, and the evaluation of supplier performance.

### 3.2.6. Environmental criteria

As described in Section 2.3, we examined the articles' description and/or discussion of environmental criteria from a product level and an organizational level perspective. Therefore, each article was classified as focusing on product-related environmental criteria or organization-related environmental criteria, focusing on both, or not specifying any types. In addition, we also recorded the concrete environmental criteria within these two main categories. To our knowledge, this characteristic of environmental criteria has never been examined in previous studies.

## 4. Results

We analyzed 60 articles which were identified by the method described in Section 3. An overview of the articles reviewed is shown in Appendix A. It presents the basic attributes for each

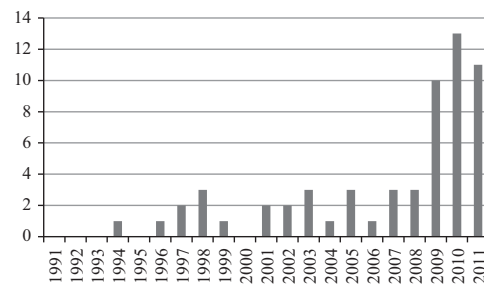


Fig. 4. Number of publications on GSS.

article such as research type, theoretical perspective, supply chain position, supplier selection process, and environmental criteria. The articles are numbered from 1 to 60, making it easier to refer to them later.

Concerning the reliability of the material selection and data analysis, the first author selected most of the research material, but all three authors jointly determined the classification categories. In cases where the classification of an article was not obvious, it was discussed jointly by the first and second authors. For the purpose of transparency, a table which presents the classification results of all the articles is attached as Appendix A, so that other researchers may verify our analysis.

### 4.1. Year of publication

As shown in Fig. 4, no article on GSS is found until the early 1990s. The first article discussing GSS was published in 1994. After this, publications on GSS were infrequent, until 2001. The first study we identified as addressing the environmental aspects in supplier selection was done by Lloyd (1994). He explores what methods should be used for evaluating suppliers' environmental performances. A study by Lamming and Hampson (1996) followed, which Shaik and Abdul-Kader (2011) identify as the first study addressing environmental criteria in purchasing. The study comprehensively identifies the environmental issues in supply management practices. Since 2001, articles on GSS have been published constantly, and in the last three years the number of publications has grown substantially.

### 4.2. Research type

We follow the classification of research type suggested by Wacker (1998) as described in Section 3.2.2. As illustrated in Fig. 5, analytical mathematical research is dominant, and accounts for 26 articles (43%) of the literature on GSS. Analytical conceptual research was used in 11 articles (18%). We did not identify any single analytical statistical study. Empirical research accounts for 23 studies (39%), and 13 articles (22%) out of these 23 take a statistical approach. Most of them employ the questionnaire survey method or database investigation for data collection.



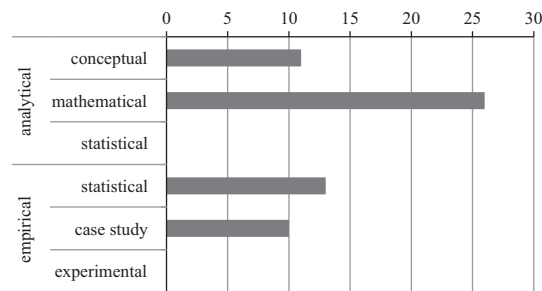


Fig. 5. Research type of the literature on GSS.

The remaining 10 articles (17%) rely on case studies which typically use interviews as the main method for data collection.

In the sections below, we describe the main results of the papers found under the different categories of research type. It should be noted that in most papers GSS is the main topic. However, some papers (Foerstl et al., 2010; Gavronski et al., 2011; Koplín et al., 2007; Paulraj, 2011; Tarantini et al., 2011) report findings on GSS as part of another main topic.

#### 4.2.1. Analytical conceptual research

Most of the analytical research focuses on 'how' to incorporate the environmental aspect in supplier selection (Chen, 2005; Humphreys et al., 2003a; Humphreys et al., 2003b; Noci, 1997; Shaik and Abdul-Kader, 2011). Noci (1997) and Humphreys et al. (2003a, b), as well as Shaik and Abdul-Kader (2011) present different frameworks for choosing environmental criteria, and suggest certain approaches for including the "green" concept in the practical assessment of suppliers. The environmental criteria are dealt with as a stand-alone issue by Noci and Humphreys et al., and only Shaik and Abdul-Kader address the environmental aspect as needed to be integrated into other aspects. The framework suggested by Chen (2005) has two stages. The first stage considers the environmental management system certification, such as ISO14001, as the minimum requirement, while the second stage screens the suppliers by requirements other than the environmental ones.

Other subjects in the category of analytical conceptual research vary. First, the Ishikawa diagram, originally a tool for quality management, is suggested by Enarsson (1998) as an applicable tool in considering environmental aspects. Second, the question of 'how environmental criteria should be identified' is a focal point in two articles (Lloyd, 1994; Huang and Keskar, 2007). Both studies argue that a set of environmental criteria should be selectively configured based on a firm's business strategy. Third, Lamming and Hampson (1996) and Preuss (2002) discuss the role of GSS in supply chain management. The last subject is the focus on life cycle assessment (LCA). The study by Baitz et al. (2005) implies that LCA-based information could effectively be used in the early decision-making stage in purchasing.

In summary, there are different approaches of integrating environmental aspects in supplier selection. In addition, there are discussions on the role of GSS in supply chain management as well.

#### 4.2.2. Analytical mathematical research

These articles deal with tools or techniques on how to process the various types of data and information for the final decision. The tools and techniques employed vary among the articles. In addition, the viewpoint taken on the environmental aspects varies as well. Some discuss how to evaluate a supplier's environmental performances, such as environmental consciousness, the

use of hazardous substances, manufacturing processes, or waste management, without addressing conventional criteria such as cost, quality, and the ability to deliver on time (Awasthi et al., 2010; Deng and Xu, 2010; Hsu and Hu, 2009; Lu et al., 2007; Tseng, 2010; Tuzkaya et al., 2009). The majority of the articles, however, aim to develop techniques for adding environmental criteria to the conventional ones in supplier selection. The remaining articles study how to mathematically model the three dimensions of sustainability: economic, environmental, and social issues (Bai and Sarkis, 2010; Büyükožkan and Çifçi, 2011; Dou and Sarkis, 2010; Kuo et al., 2010).

#### 4.2.3. Empirical statistical research

The majority in this category examine the actual practices of green purchasing in the private and/or public sector. Three articles focus on the private sector (Min and Galle, 1997, 2001; Nawrocka, 2008) and they conducted survey questionnaires and interviews, respectively. Four articles are identified in the public sector (Nissinen et al., 2009; Parikka-Alhola, 2008; Sporrang and Bröchner, 2009; Zhu and Geng, 2001). These studies consider the status quo, problems and drivers on GSS in different purchasing situations and in different countries. Both the public and private sector are examined in three articles (Holt, 2004; Michelsen and De Boer, 2009; Varnäs et al., 2009).

Two articles discuss green supply management from the resource-based view (Barney, 1991). They argue that internal resources, such as green process management (Gavronski et al., 2011) and strategic purchasing (Paulraj, 2011), are positively related to green supply management, in which green supplier selection is one of its components.

In summary, the dominant subject in empirical statistical research is describing current practices of green purchasing in the private and/or public sectors.

#### 4.2.4. Empirical case study

The outstanding feature in this category is the actual extent to which environmental requirements are used in the supplier selection process by firms in different countries (Deans, 1999; Jabbour and Jabbour, 2009; Vanalle et al., 2011; Wolf and Seuring, 2010). While some researchers find that environmental requirements were not well incorporated in the supplier selection process (Jabbour and Jabbour, 2009; Wolf and Seuring, 2010), Vanalle et al. (2011) find that data about the environmental aspects were required as concrete selection criteria. Deans (1999) observes the effectiveness of guidelines which contained concrete environmental requirements. In the case of purchasing paper products by both the private and public sectors, environmental criteria are identified, but it is still unclear how the environmental criteria are balanced with other criteria (Polonsky et al., 1998).

Other articles cover different subjects in various contexts. The topics are: a conceptual framework for incorporating sustainability into supply management, which is developed based on the case of an automotive firm in Germany (Koplín et al., 2007), the green public procurement of computers in the US (Li and Geiser, 2005), the impact of supplier evaluation on a firm's environmental initiative (Walton et al., 1998), using LCA information in supplier selection in the public procurement of building materials (Tarantini et al., 2011), and supplier management in terms of sustainability risk assessment in the chemical industry (Foerstl et al., 2010).

In short, the papers using empirical case study vary considerably in terms of focus. Some examine the current practice of green purchasing, while others identify facilitators, or address useful tools or models for GSS.

#### 4.3. Theoretical perspective

We found a clear use of specific theories such as the resource-based view (Gavronski et al., 2011; Paulraj, 2011; Preuss, 2002), the dynamic capabilities view (Foerstl et al., 2010). These are the only apparent theories we could identify in the reviewed articles. In the remaining articles, no clear theoretical perspective could be detected. It is surprising that stakeholder theory, which turned out to be the most prevalent theory in the literature on green supply chain management (Carter and Easton, 2011), is not referred to in any of the articles. Given the study by Carter and Easton (2011), one would perhaps also expect the use of transaction cost economics, but we found no articles using this theory either. Neither did we find articles using other possibly relevant theories, such as agency theory or population theory (Sarkis et al., 2011). This finding supports Seuring and Müller (2008), who conducted a literature review on sustainable supply chain management and found that a theoretical background was often missing.

#### 4.4. Supply chain context

Our study shows that 33 of the articles discuss GSS in the context of having an end-product manufacturer, a construction company, a service provider, or a more upstream organization as a purchaser (classification 1). The dominant case is an end-product manufacturer as a purchaser. Eight articles focus on supplier selection, with a public or private sector user as the purchaser (classification 2). Only two articles consider both the supply chain positions above (Baitz et al., 2005; Holt, 2004) (classification 3). It should be noted that one quarter of the articles do not specifically indicate the supply chain position.

Even though the supply chain position is detected in 43 of the articles, discussion of the issue of power balance is rare. A survey by Holt (2004) discovered that smaller firms had significantly lower influence on their suppliers than large firms. Min and Galle (2001) argue that large firms are likely to mandate their suppliers' environmental commitment due to their greater bargaining power.

Discussion of both the purchasers' and suppliers' sides is identified in three articles (Holt, 2004; Michelsen and De Boer, 2009; Wolf and Seuring, 2010). They reveal the discrepancies between purchasers and suppliers. Perception differences are uncovered by Michelsen and De Boer (2009), regarding the frequency and importance of environmental requirements formulated by the purchasers, and by Holt (2004) regarding the rejection of bids for environmental reasons.

In short, the latter two elements of supply chain context are, in most cases, not a main discussion point in the GSS literature.

#### 4.5. Supplier selection process

Fig. 6 shows which stages of the supplier selection process the articles discuss. Stage (1) "Formulation of criteria", including

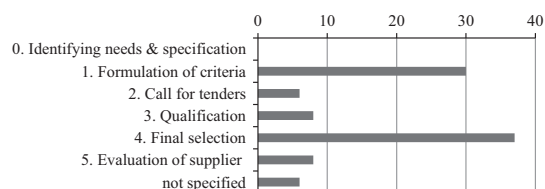


Fig. 6. Focus of the literature on stages in the supplier selection process. \*The numbering labels of stages correspond to the numbers of supplier selection process column in Appendix A.

selecting and weighting the criteria, and stage (4) "Final selection" are most often discussed, in 30 and 37 studies respectively. The fact that most of the studies which look at the final selection also consider how to assign weights to criteria explains why these frequencies are similar. We find no studies that deal with stage (0) "Identifying needs and specification". It may be because this stage is situated far ahead of the actual selection process. Stage (2) "Call for tenders" and (3) "Qualification" are focused on in six (10%) and eight articles (13%), respectively. This percentage of the qualification stage is similar to what Wu and Barnes (2011) present. They investigated the literature on general supplier selection models and identified 14% of the articles addressing qualification. Stage (5) "Evaluation", i.e., the evaluation of the supplier's and the product's performance after delivery, is focused on in eight articles. Given that valuable information from this process is directed back to the previous processes, one would perhaps have expected more attention to this stage in the literature. And lastly, six articles do not define clearly which stages of the supplier selection process are considered.

In summary, the final selection stage has the most attention in the GSS literature, while the early stages and post-selection stages are almost neglected.

#### 4.6. Environmental criteria

Taken together, the analysed articles mention many environmental criteria, but the classification of the criteria into different groups varies among the studies. Several researchers introduce their own classifications and present various concrete environmental criteria in each classification. Lloyd (1994) classifies environmental criteria into two main groups: environmental criteria related to products, and criteria related to the supplier. Enarsson (1998), Chen (2005), Handfield et al. (2002), Huang and Keskar (2007), and Parikka-Alhola (2008) use similar ways of classifying environmental criteria. Another method of classification is employed by Humphreys et al. (2003a, b), who distinguish between quantitative criteria and qualitative criteria, still the distinction between product-related and organization-related criteria prevails in the literature on GSS.

According to this distinction, more than half of the articles consider both product-related and organization-related criteria. Ten articles mention only organization-related criteria, while three articles only use product-related criteria. Six articles state the term 'environmental criteria' without further specifying them. Seven articles do not specifically mention environmental criteria. Thus, 78% of the articles mention either product-related or organization-related criteria or both. Nonetheless, it is not clear whether authors are aware of this distinction.

When we look at concrete environmental criteria presented in empirical studies, we observe that organization-related criteria typically include a certification of the environmental management system, an environmental policy, compliance to regulations, and an evaluation of the second tier suppliers' environmental performances. Typical product-related criteria include reduced use of toxic substances, recyclability, environmental labelling, and the recycling of packaging. When it comes to the environmental criteria suggested in the analytical studies, staff training for raising the awareness of environmental consideration and green market share are distinct organization-related criteria. The use of green technology and reduced use of resources are distinct product-related criteria. Interestingly, they are not seen in the empirical studies. Environmental criteria which are concerned with waste management are common in both empirical and analytical studies.

In short, most articles cover both product-related and organization-related criteria, yet empirical and analytical studies

clearly seem to focus on different sets of criteria within these classifications.

## 5. Analysis and discussions

In this section, we will first present the key findings that resulted from our analyses across the categories presented in the previous section, in order to identify how GSS has developed during the past two decades and which characteristics are discernible. Then, based on the analyses, as well as the results from Section 4, we will explain how we identify what could be the key useful dimensions of GSS.

### 5.1. Analysis of the publication distribution

GSS has only recently begun to emerge as a more recognizable body of knowledge. It is still an immature field. As seen in Fig. 4, few studies existed at the beginning of the 21st century. Since then, more and more studies have sought to incorporate environmental aspects in the supplier selection process. The spike in 2010 and 2011 in Fig. 4 can, to some extent, be explained by multiple publications by the same authors: article no. 2 and 3 (Bai and Sarkis), no.5 and 6 (Büyükköçkan), no. 7 and 8 (Che), no.28 and 29 (Kuo) and no.50, 51 and 52 (Tseng). While this particular increase on research activity on GSS can be said to have taken place in a somewhat narrow area, the articles are original in terms of methods used and their contribution.

Next, we analyze the trend in terms of the research type employed. Table 2 presents the development in publications by research type. We can observe an increase in research output over the past few years caused by the apparent popularity of applying analytical mathematical research to GSS, especially mathematical modelling. This popularity of mathematical modelling in GSS research seems out of sync with the arguments of Huang and Keskar (2007). They consider supplier selection in general, not limited to GSS, and argue that while strategic thinking can provide qualitative solutions, a mathematically optimal solution has no meaning if it does not match a firm's business strategy. There is a need to integrate strategic thinking with quantitative optimization. Furthermore, articles dealing with the mathematical modelling are usually extended applications of models which have already been developed for conventional supplier selection. Therefore, the relative contribution of such analytical mathematical studies to the development of the GSS field is limited.

### 5.2. Identifying the key dimensions of GSS

Although relatively few in number, several authors (see Section 4.2.1) stress the importance of aligning green supplier selection with the wider (green) strategy of the organization or corporation. Shaik and Abdul-Kader (2011) state that (p. 54): "...the selection of the best supplier must be driven by a manufacturer's (OEM) green supply chain strategy, which is a high-level management decision".

In a similar vein, but almost ten years earlier, Preuss (2002) argued that (p. 313): "...greener supply requires...above all, a greater role in corporate strategy making". Koplín et al. (2007) also argue that the successful integration of environmental and social aspects in the purchasing processes requires firms to align these with their corporate strategies and policies. Aligning green supplier selection with the organization's overall strategy requires that the general concept of "green" is made more concrete for the purpose of applying it in supplier selection. Thus, effective GSS starts by defining what "green" really means in a given organization, and, based on that, meaningful green supplier selection criteria can be formulated. *Aligning supplier selection with an organization's overall green strategy* and deriving meaningful green selection criteria is put forward as the first key dimension of a conceptual model of GSS.

The second key-dimension which we put forward deals with *the role of decision-making tools and models in GSS*. As mentioned before, and referred to in Sections 4.2.2 and 5.1, the review showed that many papers focus on mathematical techniques for aiding purchasers in the actual assessment and weighing of environmental criteria. The fact that most GSS research falls in this category does not necessarily mean that all of this research is "demand-driven". Still, as Preuss (2002) argues (p. 313): "Environmental questions are more complex than traditional sourcing issues in that their time scale is longer and the interaction between individual variables more complex. Consequently, addressing environmental issues in the manufacturing supply chain can be hampered by problems inherent in the decision-making process". It seems reasonable to assume that the inclusion of environmental criteria does not make supplier selection easier, and that some tools assisting decision-making are necessary in practice or should be at least considered, hence we include this issue as a key-dimension of a conceptual model or GSS.

The third key dimension we suggest consists of *considering GSS as a series of interrelated decisions and information processing activities* rather than a single, isolated choice. Referring to the general process model of supplier selection, see Fig. 1, the literature review resulted in a set of GSS papers, which, taken together, address almost all of the stages in supplier selection, from the early stages such as formulating criteria and qualifying potential suppliers, to the final stage of selecting the ultimate bid. Clearly, most, and perhaps too much, attention has been paid to models for the final selection stage, but the importance of the early stages is clearly addressed as well. Deng and Xu (2010), for example, emphasise the need to first screen the set of potential suppliers in order to eliminate those whose environmental stances may conflict with the buying firm's own stance. Others, such as Huang and Keskar (2007), focus specifically on defining an appropriate set of green supplier selection criteria, deeply grounded in a firm's strategy. Therefore, the results of the literature review suggest that "greening" supplier selection may or perhaps should concern all stages in the process. Specific environmental criteria are suggested and addressed in both the analytical and empirical GSS research, but where in the process should they be concretized

**Table 2**  
Development in the GSS research by research type.

Research type		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Analytical Research	Conceptual	1		1	1	1				1	2		2		1				1
	Mathematical Statistical									1	1			1	1	1	4	11	6
Empirical Research	Statistical				1				2			1				2	5		2
	Case study Experiment					2	1						1		1		1	2	2

and communicated toward suppliers? We argue that effective GSS requires a rather deliberate design of the selection process in which the need and possibilities for “greening” are considered in each stage, and which secures coherence throughout the entire process.

The fourth and final dimension we suggest concerns the importance of *considering the wider supply chain context in which GSS takes place*. Following our literature review we distinguish between three aspects of supply chain context: (a) the position of the focal organization in the supply chain, (b) the power, vis-à-vis suppliers, that can be exerted by the focal organization undertaking the selection, and (c) inter-organizational issues of supplier selection. i.e., the degree of perceptual discrepancies between the focal organization and the suppliers regarding the meaning, importance and use of green criteria. Whilst few of the reviewed GSS articles specifically address the issue of “supply chain context” as such, there are several, clear references to one or more of the three aspects above, and we argue that they are important for effective GSS.

Several papers point to the relevance of the supply chain position (a) when considering the effectiveness of GSS. Nawrocka (2008) refers to Hall (2001), who concludes that green incentives for firms are different depending on the specific position in the supply chain. It seems, pressure from final customers and users diminishes as one moves further up the supply chain (Nawrocka, 2008). This is in line with Preuss (2005) who argues that depending on where an organization is positioned in the supply chain, the external pressure (from public opinion, governments and NGOs) to take environmental aspects into account may differ. As a result, the content, weight and impact of green criteria, as well as the ease of changing these criteria, are likely to differ throughout the supply chain.

Power also matters (b), when it comes to forcing a supplier to improve its environmental performance and creating the so-called green multiplier effect in the supply chain (Preuss, 2002). Based on an extensive study of small firms, Nawrocka (2008) concludes that: “...another factor that affects the possibilities for companies to develop green supply chain programs...is their level of influence” (p.357). Although power is a multifaceted concept, it seems likely that larger buying firms can exert more power upstream in the supply chain (Holt, 2004; Min and Galle, 2001) and hence, they should be able to include more (ambitious) green criteria in their selection process than smaller, less powerful firms. Less powerful firms, however, may still be able to adjust their environmental

requirements to the supplier that is perceived to be “best in class” when it comes to environmental performance, both internally and further upstream in the supply chain.

Finally, regarding perceptual discrepancies (c), while the existing GSS papers typically view GSS as an “internal activity” carried out by the firm's purchaser, several papers report on the discrepancies between a supplier's perception of environmental requirements and the purchaser's perception of those requirements (Holt, 2004; Michelsen and De Boer, 2009; Wolf and Seuring, 2010). Green supplier selection criteria do not necessarily play the role they are assigned to on paper. As illustrated in one of the interviews carried out by Nawrocka (2008): “...in most cases ‘the environmental criteria are paid lip service in the selection process, it is the money that decides’ as one of the respondents phrased it (p. 356)”. If green criteria are not really taken seriously by the buying firm, it is doubtful if the suppliers will understand their significance, as is also suggested by Michelsen and De Boer (2009). If the green dimension in supplier selection is to make a real difference, the buying firm should consider which criteria it really can commit to and use convincingly in relation to the suppliers. This requires insight into how the suppliers view the buying firm's GSS practice.

Summarizing, based on the literature review we have identified four key dimensions of GSS.

- Aligning supplier selection with an organization's overall green strategy
- The role of decision-making tools and models in GSS
- GSS as a series of interrelated decisions and information processing activities
- The wider supply chain context in which GSS takes place

## 6. Development of a conceptual model of GSS

Using the dimensions arrived at in the previous section, a conceptual model of GSS is suggested (see Fig. 7). The purpose of the model is threefold. First, it acts as a qualitative synthesis of the results of the past 20 years of research on GSS, by identifying, and combining important aspects of GSS into one model. Second, the model can be used by researchers as a tool for identifying fruitful directions for further research and a framework for possible reviews of GSS literature in the future. Third, purchasers, consultants and policy-makers may consider it as a tool for

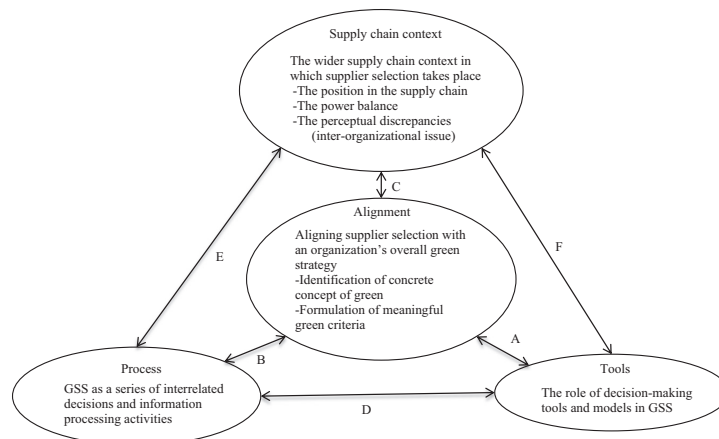


Fig. 7. Conceptual model of GSS.

assessing and developing the GSS practice. We shall return to the latter two purposes in the final section of the paper. First, in this section, the model is worked out in more detail, both in terms of the individual dimensions and their interrelationships.

### 6.1. Aligning supplier selection with an organization's overall green strategy

The first dimension deals with the need to develop an understanding of what "green" means in relation to an organization's overall strategy, and consequently, which aspects should be considered important in the context of the organization's purchasing function, in particular when it comes to selecting suppliers. Without such an understanding, the list of possible environmental criteria to include and use in a decision model may become endless and the green dimension of the selection may lose its significance. In addition, without making the implications of "green" sufficiently understood for supplier selection, it will be difficult for purchasers to effectively and convincingly communicate the criteria to the suppliers.

Such alignment, however necessary, will not be easy to achieve quickly. In terms of *Simon's (1964)* model of an organization as a complex, loosely coupled network of decision-making processes, the challenge of supplier selection is to find or develop green supplier selection criteria that will contribute to achieving the firm's overall green objectives without simultaneously making the firm violate other fundamental goals, such as profit or quality. This implies a gradual process of incorporating "green" as a constraint at various levels in the organization, both strategic and operational, such that feasible solutions can be found at each level in relation to all the relevant constraints at that level, not only the green one. This is in line with *Carter and Rogers' (2008)* more general argument in relation to sustainable supply chain management (SSCM) that: "...environmental dimensions of SSCM...must be undertaken with a clear and explicit recognition of the economic goals of the firm" (p.389). In other words, effective and aligned GSS criteria are criteria that both contribute to the overall green objectives of the firm and enable the selection of suppliers that satisfy other constraints as well. Adopting this perspective, it becomes clear that not necessarily any given green criterion can be used or makes sense.

It also implies that effective GSS is more than just adding one or another green criterion to the established criteria in a supplier selection process. Just as the established criteria are not chosen randomly, but have a particular function (namely to ensure that the higher level ambitions of the firm, for example in terms of cost level, market share, and worker satisfaction, etc., are achieved), the green criteria cannot be chosen randomly either if they are to be effective.

Given the fundamental importance of this dimension, and inspired by *Cousins et al. (2008)*, it is positioned centrally in the model, with clear implications for the other three dimensions. We shall first discuss the three other dimensions in the model before returning to the interrelationships between all of the dimensions.

### 6.2. The role of decision-making tools and models in GSS

Once the strategic meaning of 'green' has been identified and made more concrete for supplier selection, tools for supporting green supplier selection processes should be considered, leading to the second dimension in our model. The need for some form of decision support seems reasonable, given that consideration of environmental aspects further complicates supplier selection in the sense that more criteria must be evaluated and possibly traded off against each other. In addition, as pointed out earlier in the paper, GSS will typically involve applying a longer time

perspective when trying to consider the consequences of choosing one supplier over another. Furthermore, despite the lack of consensus on the usefulness of decision support systems and models in general, recent research by *Kaufmann et al. (2012)* suggests a clear and positive relationship between a highly analytical approach to supplier selection and the quality of the decision outcome, measured in terms of financial and non-financial supplier performance. The results of *Kaufmann et al. (2012)* are in line with the conclusions of earlier work in this area by *De Boer and Van der Wegen (2003)*.

Still, as the literature review in this paper also pointed out, there are vast amounts of models to choose from, and, again referring to *De Boer and Van der Wegen (2003)*, different supplier selection situations will probably require different decision models. What constitutes an appropriate set of decision models for GSS in a particular organization is therefore not obvious and needs to be seen in relation to the other dimensions in the conceptual model of GSS.

### 6.3. GSS as a series of interrelated decisions and information processing activities

Given that an organization has developed an initial understanding of what green means in the context of supplier selection, the question of how and to what extent this understanding should be applied in the various stages of the supplier selection process remains. Formulating criteria is the key stage in aligning supplier selection with the green strategy of the firm. As the literature review revealed, green supplier selection criteria may be directed more specifically to the supplier as an organization or to the product or service purchased from the supplier. Organization-related criteria will be most important in the stage of qualifying suitable suppliers while product-related criteria are typically dominant in the final stage of the selection process when considering the proposals from the qualified suppliers (*Fet et al., 2011; Parikka-Alhola, 2008*). Both types of criteria may be relevant when evaluating the performance of the chosen supplier during the delivery and use of the product or service supplied. It seems important to make sure that the various green criteria applied in the different phases, taken together, constitute a coherent set aligned with the overall green strategy. This may not be easy or self evident. For example, the firm may be under pressure to accept or use a specific requirement regarding the amount of hazardous materials that may be in a product it purchases. The question, then, is if that requirement, which is product-related in nature, should only be applied in the final stage of selection as an "order winner" (*Hill, 1989*) or if a "matching" organization-related criterion should be developed as an "order qualifier" (*Hill, 1989*) that identifies suppliers which actively look for alternative less hazardous materials.

Another complicating factor, which is not unusual for purchasing processes in general, is that multiple people representing different functions are involved in the various stages of the selection process. Purchasers may be typically involved in the later stages when choosing among tenders and proposals, whereas Quality Control or Environmental Management representatives may focus more on the formal qualification of suppliers, or on measuring the performance of the suppliers ("post selection"). Effective GSS involves becoming aware of the fragmented nature of the supplier selection process and aiming at achieving coherence throughout all the stages of the process.

### 6.4. The wider supply chain context in which GSS takes place

The fourth dimension in the conceptual model concerns the need to consider GSS in a wider context. Clearly, in terms of their

position in the supply chain, most organizations are both supplier and customer, and thereby play a role in passing through environmental requirements throughout the supply chain. Research suggests that this process is not without challenges (Nawrocka, 2008; Preuss, 2002). We argue that effective GSS must include an assessment of the wider organizational and inter-organizational context. In that way, the focal organization can become aware of its limitations and possibilities when it comes to greening the supplier selection process. Is the purchasing organization aware of the power balance in the supply chain? Do suppliers understand and accept the green criteria put forward by the purchasing organization, and just as important, do the suppliers understand why the purchasing organization uses these criteria, i.e., do they understand the connection (alignment) between the green selection criteria and the overall green strategy of the purchasing organization? How much pressure can or should the purchasing organization exert on the different suppliers to adapt to demands for more sustainability? Walker et al. (2008) find that suppliers not necessarily wish to share environmental information. But also, does the purchasing organization really understand the supplier's strategic view on "green", and how the supplier has aligned its functional strategies with this view? Is the purchasing organization aware of possible supplier initiatives, for example voluntary and industry-specific certification (Walker et al., 2008)? The answers to these questions are likely to have implications for one or more of the first three dimensions.

#### 6.5. Interrelationships among the four key dimensions

An important feature of the conceptual model is the recognition of the interrelationships between the four key dimensions. We argue that changes in, or decisions regarding one particular dimension, are likely to have consequences for the other three dimensions. By explicitly considering these relationships, both researchers and practitioners can achieve a more comprehensive and holistic approach to GSS. We shall address relationships between these dimensions below.

First of all, and as pointed out in Section 6.1, the central dimension of the model, 'the alignment of supplier selection with the overall green strategy of the organization', by definition has important implications for all three other dimensions. The outcome of the alignment process is an understanding of what "green" means for the organization, and, more specifically, is a basic set of green criteria for supplier selection that is relevant for the organization.

Choosing and using decision-making tools in GSS, as discussed in Section 6.2, requires the specification of relevant green criteria and information about the decision-maker's preferences. Without knowing the results of the alignment process, i.e., what the relevant green criteria are, there will not be a clear basis for using a decision-model. Decision-making tools are only abstractions; they first become valuable when the decision-maker "feeds" them with data and preference information (relationship A in Fig. 7).

The basic set of green criteria that results from the alignment process will also provide the starting point for finding out in more detail which of the green criteria apply to the suppliers and which apply to the products and services purchased. In other words, the design of the selection process in terms of the various stages as discussed in Section 6.3 is also dependent on the results of the alignment process (relationship B in Fig. 7).

The results of the alignment process are also likely to influence the assessment of the wider supply chain context as described in Section 6.4. Once a clearer picture exists of which basic green criteria the organization wishes to focus on, it will also become clearer which parts of the business environment are most relevant, i.e., which suppliers and other relevant actors in the supply chain. The assessment of the power balance in a supply chain is likely to

be more precise if more is known about the particular issues at stake (relationship C in Fig. 7).

While the above descriptions of the relationships A, B and C consider how the central "alignment" dimension influences the other three peripheral dimensions, we suggest that, next, based on actual experiences of the firm with implementing GSS, important insights may be fed back to the central dimension of alignment. For example, as a result of applying certain decision tools for GSS in various stages of the supplier selection process, the insights obtained about the effectiveness of the GSS practice may lead to a "bottom-up" driven process of reconsidering or adjusting the green strategy of the firm and the ways purchasing can best contribute to that strategy. Furthermore, an important finding by Walker et al. (2008) in their analysis of drivers and barriers of environmental supply chain management concerns the strength of external drivers on a firm's overall green strategy and initiatives. Mapping the wider supply chain context of GSS is therefore not only driven by the initial results of aligning supplier selection with the overall green strategy but is also likely to provide valuable insights in return, e.g. about external opportunities or barriers that may serve as input to the alignment process.

There are also important relationships between the three peripheral dimensions in the conceptual model, which we shall address here. Similar to the relationships A, B and C, these relationships are bidirectional rather than one directional.

A clear relationship exists between the tools and process dimensions. As we know from earlier, more general reviews of the supplier selection literature (De Boer et al., 2001; Wu and Barnes, 2011), the different stages in the process require different types of decision support. For example, supplier qualification is typically about screening a larger set of potential suppliers for a smaller set of qualified suppliers. This sorting process is technically different from the ranking process typically found in the final selection stage. Therefore, depending on the particular stage in the selection process under consideration, different decision-making tools may be relevant. Conversely, when considering the adoption of a particular decision-making tool, it is important to consider which stage(s) in the selection process is(are) covered by this particular tool (relationship D in Fig. 7).

The process dimension should also be seen in relation to supply chain context dimension. From the literature review we learned that the supplier may not necessarily understand and acknowledge the way the purchasing organization uses the information provided by them in the supplier selection process. Therefore, from the perspective of the purchaser, it is important to consider more specifically if suppliers receive enough, and appropriate information in each of the stages of GSS, and how the gaps between the perceptions of suppliers and purchasers can be reduced in each stage (relationship E in Fig. 7).

In a similar way, the choice for a particular decision-making tool and the supply chain context are related. Certain decision-making tools may require more detailed information and a higher degree of openness and collaboration from the suppliers. The lack of information sharing with suppliers is pointed out by Nawrocka (2008), Wolf and Seuring (2010) and Walker et al. (2008), as a possible barrier to green supply management. The willingness of suppliers to share information with the purchasing organization, or to spend resources on providing the information in the form requested by the purchasing organization, may depend on the power balance in the supply chain. Highly advanced decision-making tools requiring the gathering of specific data throughout the upstream supply chain may not be very suitable unless the purchasing organization is powerful enough to persuade suppliers to accept the use of this model (relationship F in Fig. 7).

Lastly, similar to the logic of the Supply Wheel Model developed by Cousins et al. (2008), we argue that effective GSS requires

an appropriate balancing of the efforts dedicated to each of the dimensions. Overemphasizing certain dimensions, for example by writing elaborate “green strategy” documents without considering the appropriate decision tools for executing green supplier selection is unlikely to be effective. The same would be true for the opposite: spending a lot of resources on developing advanced systems for evaluating green criteria in supplier tenders may prove difficult without having a sense of direction in terms of how suppliers are supposed to contribute to the overall strategy of the organization. In addition, both the operational decision tools and the green strategy of the organization should match the position and role of the organization in the supply chain.

## 7. Conclusions, further research and implications

This paper has analyzed two decades of literature on GSS from various viewpoints. We now return to the main questions to be answered in the paper: “What characterizes the existing studies on green supplier selection?”, “What are the unaddressed or overlooked areas within green supplier selection research?” and “What could be the future directions of research into green supplier selection?” We address each of these questions and elaborate on the implications for practitioners and policy-makers.

### 7.1. What characterizes the existing studies on green supplier selection?

We conclude that after many years with modest attention to GSS, the volume of GSS research has grown strongly, especially during the last three years. Analytical research focusing on the final stage in GSS is clearly most dominant. The articles in this category employ a wide range of methods and techniques from Operations Research and bear a close resemblance to previously suggested decision models for supplier selection more in general. Empirical research is less prominent than analytical research and the private sector is more frequently targeted than the public sector. Much of the empirical research lacks a clear theoretical background. Another stream of GSS research is conceptual research, which mainly develops conceptual frameworks for integrating environmental aspects in supplier selection. Overall, in terms of the research approach taken in the articles, GSS research seems fragmented and in danger of overemphasizing the technical and operational aspects of supplier selection.

In terms of the subjects addressed, two dominant foci are identified: the integration of environmental aspects into supplier selection processes and the mapping and analysis of current GSS practices. Recently, other topics, such as the use of information from LCA, applying ideas from the resource-based view to green supply management, and GSS in the public sector, have emerged.

Looking at the environmental criteria in supplier selection, the distinction between product-related criteria and organization-related criteria appears as a natural and useful way of classifying them. However, it remains unclear how many authors use this distinction deliberately, as most articles do not address their viewpoints on this, but merely list the various kinds of concrete environmental criteria.

### 7.2. What are the unaddressed or overlooked areas within green supplier selection research?

This study uncovers a number of weak areas in the existing literature on GSS. As described earlier, the literature on GSS pays a lot of attention to the final stage in the supplier selection process. This finding is in line with the literature on supplier selection in general (De Boer et al., 2001; Wu and Barnes, 2011). The needs-identification

stage is not addressed in any of the GSS studies reviewed. Formulating criteria is seldom mentioned, the focus in most cases is on weighing criteria. Also, the stage of qualification receives relatively little attention. These early stages in the supplier selection process influence the effectiveness and quality of the stages later in the process, and deserve more attention.

Another weak area is related to the lack of recognition of where in the supply chain the studies of GSS are positioned. Discussion of the influence of the supply chain position considered in a GSS study is generally lacking, and a quarter of the articles do not specify the position in the supply chain at all. The perspective of looking at supplier selection in a dyadic relationship is also lacking. In addition, the public sector needs to be focused on as well as the private sector. A greater sense of awareness of the supply chain context considered in a study and its influence on GSS could lead to a more substantial discussion and comparison among studies.

In terms of the research types applied to GSS, the current literature shows an unbalance in relation to the topics studied. The articles dealing with the topic of “incorporation of environmental aspects” are almost exclusively based on analytical research approaches and in clear need of empirical research, especially in the form of case studies or field experiments that could shed light on the practical effectiveness of the many decision models developed through analytical research. On the other hand, most of the studies dealing with the topic “current practices of GSS” are based on empirical research. In most of these studies, a theory-driven conceptual framework is lacking, particularly when it comes to linking GSS to an organization’s strategy. To fill these gaps more analytical conceptual research is called for. This is in line with the findings in a literature review by Hoejmose and Adrien-Kirby (2012), which focuses on socially and environmentally responsible procurement.

### 7.3. What could be the future directions of research into GSS?

Based on the previous sections, and building further on the conceptual model of GSS developed in this paper, we address the final question regarding directions of future research. Following our conceptual model, based on our review of all the relevant articles, we argue that ideally, GSS research should cover four dimensions: (1) “Alignment”—a conceptual, strategic dimension, aimed at providing a decision context and at securing alignment with the overall strategy, (2) “Tools”—a technical, operational dimension aimed at devising and choosing appropriate tools for information processing and decision support, (3) “Process”—an operational and processual dimension aimed at drawing appropriate attention to the interrelated stages in a GSS process, and (4) “Supply chain context”—a supply chain positioning dimension, also of strategic importance, and necessary for considering how to make effective green supplier selection decisions, given the power structure in the chain.

The few, but valuable existing conceptual studies on “Alignment” must be extended and complemented with an empirical approach. Emerging topics identified in the literature review, such as the use of LCA based information and the resource-based perspective, could contribute to such studies. Incorporating LCA-based information in and applying a life cycle perspective to management processes, i.e., life-cycle management (Seuring and Müller, 2008), is likely to help an organization align its overall green strategy with its purchasing strategy. Given the finding from a study by Giunipero et al. (2012), that the involvement of top management is the most important driver for managing sustainable supply, their specific role in the “Alignment” dimension is worth looking into as well.

Regarding the “Process” dimension, more research, both analytical and empirical, is required into the earlier stages of the GSS. When it comes to “Supply chain context”, more specific studies of upstream GSS positions would be valuable, as most of the existing studies are aimed at the downstream positions. In addition, the impact of power and discrepancies between the buyer’s and the supplier’s perspectives on GSS need further attention. It would be useful to study several supply chain stages simultaneously, rather than focusing on a specific stage. The “Tools” dimension has already received much research attention, but with an almost extreme focus on analytical research. Therefore, the main future research challenge regarding this dimension is to complement the analytical studies with more empirical work.

We would also like to stress the need for what we call “integrative” research that explicitly covers two or more dimensions. Most of the existing research focuses on only one of the dimensions. Notable exceptions are Handfield et al. (2002) and Shaik and Abdul-Kader (2011). Handfield et al. (2002) develop a framework for linking corporate strategy to green purchasing and address the use of decision models. Shaik and Abdul-Kader (2011) also propose a strategic approach to GSS. Furthermore, they illustrate the applicability of multiple attribute utility theory as a decision support tool. Still, these studies only look at one relationship. Future research should be aimed at considering multiple relationships simultaneously. Such research is clearly lacking, and is very important for gaining insight into how firms and organizations deal with balancing the four dimensions in their GSS practice, and how this practice could be made more effective. We suspect that the effectiveness of GSS is related to how well understood the consequences of decisions in one dimension relate to the others, and how well the four dimensions are balanced.

Finally, particular obstacles or notable aspects of GSS that are pointed out in the existing studies, such as the unawareness of the potential economic benefit of GSS for a purchaser, and the absence of an environmental cost measure, are also valuable issues for further research as well.

#### 7.4. Implications for practitioners and policy-makers

GSS might be seen by some as a minor extension of conventional supplier selection, simply by adding a few environmental criteria. However, our study of the literature and the conceptual model resulting from it, suggest that such a casual “add-on” approach is not likely to be very effective. There are many environmental criteria to choose from, and much time can be spent by both purchasers and suppliers on trying to find out what the counterpart really means by “green”, and how the information about green performance is or should be used in the supplier selection processes.

Our first advice to purchasers, therefore, would be to invest some time in trying to identify which aspects of “green” as a concept are the most relevant for the organization on a strategic level, both in terms of corporate strategy and purchasing strategy. Many organizations are developing Environmental Management Systems (EMS) in which they can effectively identify critical environmental aspects (Chen, 2005; Fet, 2002). The aspects identified may differ from organization to organization. For example, a paint factory may prioritize working towards eliminating certain hazardous chemicals, construction companies might focus on developing energy-efficient buildings and a university may focus on reducing waste and its treatment. We believe that

establishing a focus on a limited number of key aspects will contribute to more effective supplier selection decisions. Without such a focus and an understanding of how “green” is related to an organization’s strategy and purpose, the green dimension in supplier selection may become a thin veneer on the outside of the process, adding real value to neither the purchaser’s nor the supplier’s decisions and actions.

Given the identified key environmental aspects, a purchaser can start to translate these into specific criteria for the different stages of the supplier selection process, and consider which decision model or decision support approach is most appropriate for effectively incorporating the environmental criteria in the decision. Still, as pointed out earlier in the paper, throughout this process, the purchaser should also consciously consider the supply chain context (Walker et al., 2008). For example, depending on the relative power of certain suppliers, the purchaser might need to adjust the criteria and/or decision models initially considered (Preuss, 2001). Irrespective of the power balance, however, it is important that purchasers clearly communicate the green criteria towards the suppliers (Seuring and Müller, 2008). Again, focusing on a limited number of key aspects is likely to make this communication both easier and more concrete, and thereby more convincing for suppliers.

The literature review has revealed that GSS is a complex, multidimensional problem which requires much of a purchaser. Ideally, a purchaser should be able to understand strategic processes, recognise the strategic implications of environmental aspects, translate these implications into meaningful criteria for supplier selection, obtain insight in the wider supply chain context and be able to work with models and methods for evaluating environmental performance. This calls for developing appropriate education and training programmes for purchasers (Bowen et al., 2001; Seuring and Müller, 2008). It is often unrealistic that all these skills and competencies can be acquired by one person; therefore, purchasers, even more than before, must develop their role as facilitators of cross-functional teams in organizations (Carter and Dresner, 2001; Trent, 1998).

Finally, the paper also has implications for policy-makers trying to stimulate both the purchasers in the public sector and their suppliers to adopt “green purchasing”. If one accepts the argument, according to the conceptual model developed in this paper, that GSS must be grounded in an organization’s specific strategy and purpose, the effects of universal “one size fits all” solutions or recommendations may be limited. Developing guidelines (e.g., checklists with environmental criteria) for specific industry sectors or products may be more effective but, policy-makers should still consider the need for local alignment. Stimulating awareness among local (public) management and providing sufficient means and resources for the training and education of purchasers, may perhaps be one of the most effective ways in which higher level policy-makers can contribute to the adaptation of green purchasing.

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## Appendix A. Overview of the reviewed articles

		Research type	Theoretical perspective	Supply chain position	Supplier selection process	Environmental criteria
1.	Awasthi et al. (2010)	ana-math	NS	NS	1, 4	o, p
2.	Bai and Sarkis (2010)	ana-math	NS	NS	1, 4	o, p
3.	Bai et al. (2010)	ana-math	NS	NS	4, 5,	o
4.	Baitz et al. (2005)	ana-conc	NS	1,2	NS	p
5.	Büyükközkcan (2011)	ana-math	NS	1	1, 4	o
6.	Büyükközkcan and Çifçi (2011)	ana-math	NS	1	1, 4	o
7.	Che (2010)	ana-math	NS	1	1, 4	o, p
8.	Che et al. (2010)	ana-math	NS	1	3, 4	o, p
9.	Chen (2005)	ana-conc	NS	NS	3	o, p
10.	Deans (1999)	emp-case	NS	1	3, 4	o, p
11.	Deng and Xu (2010)	ana-math	NS	NS	3	NA
12.	Dou and Sarkis (2010)	ana-math	NS	NS	4	o, p
13.	Enarsson (1998)	ana-conc	NS	NS	4 or 5	o, p
14.	Feyzioglu and Büyükközkcan (2010)	ana-math	NS	1	1, 4	o, p
15.	Foerstl et al. (2010)	emp-case	DCV	1	5	NS
16.	Gavronski et al. (2011)	emp-stati	RBV	1	4, 5	NS
17.	Handfield et al. (2002)	ana-math	NS	1	1, 4	o, p
18.	Holt (2004)	emp-stati	NS	1, 2	4, 5	o
19.	Hsu and Hu (2009)	ana-math	NS	1	1, 4	o, p
20.	Huang and Keskar (2007)	ana-conc	NS	1	1	o, p
21.	Humphreys et al. (2006)	ana-math	NS	NS	1, 4	o, p
22.	Humphreys et al. (2003a)	ana-conc	NS	NS	1, 4	o, p
23.	Humphreys et al. (2003b)	ana-conc	NS	NS	1, 4	o, p
24.	Jabbour and Jabbour (2009)	emp-case	NS	1	1	o, p
25.	Kannan et al. (2008)	ana-math	NS	1	1, 4	o
26.	Koplin et al. (2007)	emp-case	NS	1	NS	NS
27.	Kuo et al. (2011)	ana-math	NS	1	1, 4	o, p
28.	Kuo and Lin (2011)	ana-math	NS	1	1, 4	o
29.	Kuo et al. (2010)	ana-math	NS	1	1, 4	o, p
30.	Lamming and Hampson (1996)	ana-conc	NS	NS	5	o
31.	Lee et al. (2009)	ana-math	NS	1	1, 4	o, p
32.	Li and Geiser (2005)	emp-case	NS	2	NS	NS
33.	Liu and Wu (2009)	emp-stati	NS	1	1	p
34.	Lloyd (1994)	ana-conc	NS	NS	1	o, p
35.	Lu et al. (2007)	ana-math	NS	NS	1, 4	o, p
36.	Michelsen and De Boer (2009)	emp-stati	NS	2	2, 3, 4	NS
37.	Min and Galle (1997)	emp-stati	NS	1	1	o, p
38.	Min and Galle (2001)	emp-stati	NS	1	1	o, p
39.	Nawrocka (2008)	emp-stati	NS	1	2	NS
40.	Nissinen et al. (2009)	emp-stati	NS	2	2	o, p
41.	Noci (1997)	ana-conc	NS	NS	4	o, p
42.	Parikka-Alhola (2008)	emp-stati	NS	2	2	o, p
43.	Paulraj (2011)	emp-stati	RBV	1	4, 5	o
44.	Polonsky et al. (1998)	emp-case	NS	2	NS	NA
45.	Preuss (2002)	ana-conc	RBV	NS	NS	NA
46.	Shaik and Abdul-Kader (2011)	ana-conc	NS	1	1, 4	o, p
47.	Sporrang and Bröchner (2009)	emp-stati	NS	2	2	NA
48.	Tarantini et al. (2011)	emp-case	NS	2	1, 3	p
49.	Tsai and Hung (2009)	ana-math	NS	1	4	o
50.	Tseng (2010)	ana-math	NS	1	1, 4	o
51.	Tseng (2011)	ana-math	NS	1	1, 4	o, p
52.	Tseng and Chiu (2013)	ana-math	NS	1	1, 4	o, p
53.	Tuzkaya et al. (2009)	ana-math	NS	1	1, 4	o, p
54.	Vanalle et al. (2011)	emp-case	NS	1	3,4,5	o, p
55.	Varnäs et al. (2009)	emp-stati	NS	2	1, 2	o, p
56.	Walton et al. (1998)	emp-case	NS	1	NS	NA
57.	Wolf and Seuring (2010)	emp-case	NS	2	1, 3,4	NA
58.	Yeh and Chuang (2011)	ana-math	NS	NS	4	o, p
59.	Zhang et al. (2003)	ana-math	NS	1	4	NS
60.	Zhu and Geng (2001)	emp-stati	NS	1	4, 5	o, p

**Abbreviations and notes****Research type:**

ana-conc: analytical conceptual  
 ana-math: analytical mathematical  
 emp-stati: empirical statistical  
 emp-case: empirical case study

**Theoretical perspective:**

DCV: dynamic capabilities view  
 RBV: resource-based view  
 NS: not specified

**Supply chain position:**

- 1: a first tier supplier or a sub-system provider as a supplier and an end-product manufacturer, a construction company, a service provider as a purchaser, or more upstream relation
- 2: an end-product manufacturer, a construction company, a service provider as a supplier and an end user (a government agency, a municipality or a private sector user) as a purchaser
- 3: both cases above  
 NS: not specified

**Supplier selection process:**

- 0: Identifying needs and specifications
- 1: Formulation of criteria
- 2: Call for tenders
- 3: Qualification
- 4: Final selection
- 5: Evaluation of supplier performance  
 NS: Not specified

**Environmental criteria:**

p: product-related criteria  
 o: organization-related criteria  
 NS: not specified  
 NA: not applicable

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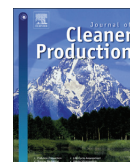
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Paper II





## Investigating the anatomy of supplier selection in green public procurement



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### ABSTRACT

Including environmental criteria in the supplier selection process complicates the decision-making of purchasers. The increasing pressure on purchasers to include environmental criteria raises the question how purchasers deal with this challenge. This paper assesses the inclusion of environmental criteria in supplier selection in the Norwegian public sector by identifying environmental criteria in official tender documents related to 41 purchases and analysing them both in a quantitative and qualitative way. The documents show that purchasers use different types of environmental criteria and that such criteria may be used in different stages of the selection process. Viewing our findings in the light of theories about behavioural decision-making, purchasers basically use four approaches for simplifying the green supplier selection problem: ignore, incorporate, insist and integrate. Typically, they avoid a direct trade-off between green performance and other classical purchasing criteria ('integrate'). It seems to be more common for purchasers to ignore environmental criteria, define them as part of other existing criteria ('incorporate'), or use them as qualifiers early in the selection process ('insist'). Policy-makers should develop policies that take into account the purchasers' four approaches. Practitioners should acknowledge these approaches to green supplier selection. This study contributes to the supplier selection literature by conceptualizing the inclusion of environmental criteria using two different decision-making paradigms and developing theoretical propositions as to how purchasers deal with the complexity of green supplier selection.

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### 1. Introduction

Green public procurement (hereafter referred to as GPP) is a prominent economic tool facilitating sustainable development. The Commission of the European Communities defines GPP as 'a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured' (The Commission of the European Communities, 2008). Public authorities have enormous purchasing power as major consumers, spending as much as 19% of the EU's GDP (The European Commission, 2011); therefore, GPP can contribute towards developing a sustainable society by decreasing indirect environmental impacts. In essence, it can reduce the CO<sub>2</sub> emissions and other environmental impacts embodied in purchased goods and services,

helping drive the market for greener products and services while setting an example for corporate and private consumers.

In implementing GPP, supplier selection is of great importance, giving the purchaser an opportunity to directly and indirectly improve environmental performance by including specific criteria in the decision-making process, i.e., green supplier selection (hereafter referred to as GSS). Despite providing this opportunity, including of environmental criteria in supplier selection adds the complexity of supplier selection because additional information must be gathered and processed; moreover, the time horizon to be taken into account when assessing environmental impact typically lies further ahead (Preuss, 2002).

An extensive literature review concludes that most existing studies focus on analytical, normative decision models of GSS that try to capture at least part of this increased complexity (Igarashi et al., 2013). Previous research (De Boer and Van der Wegen, 2003; Kaufmann et al., 2012) has shown the potential of such models for improved purchaser decision-making. Nonetheless, De Boer and Van der Wegen (2003) have found that the usefulness of a particular decision-model – as judged by professional purchasers – not only depends on how well the model captures the

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perceived complexity of the decision, but also on whether or not the costs of applying and maintaining the decision-model seem justified when considering the importance of the decision. This finding is of particular importance for GSS if it is assumed that supplier selection involving environmental criteria represents a more complex decision problem than a conventional supplier selection problem. It also underlines the need to apply a more behavioural perspective on supplier selection, acknowledging the limited cognitive and economic resources available to the purchaser when facing a complex decision problem. Based on the pioneering work by Nobel laureate Herbert Simon (1978, 1997), such a perspective suggests that purchasers will make decisions based on the principle of bounded rationality. Therefore they will adjust the depth and scope of their deliberation on environmental issues in supplier selection depending on the cognitive abilities and resources available. To the best of our knowledge, such a behavioural approach to GSS has not been applied previously. This paper thus aims to contribute to closing this gap, an important task given that an understanding of how purchasers actually incorporate environmental criteria in supplier selection is key to developing effective policies for further advancing GPP as a whole.

The primary research question is as follows: 'How do public purchasers, seen as organizational decision-makers, deal with the complexity of GSS?' More specifically, this paper seeks to uncover how purchasers include environmental criteria in various stages of the supplier selection process. The paper anatomizes actual GSS cases by systematically analysing the inclusion of environmental criteria from a behavioural decision-making perspective. In Norway, public purchasers have to file a structured summary of the supplier selection process for each major acquisition (above NOK 500,000) in a publicly available database called Doffin ([www.doffin.no](http://www.doffin.no)). In each file, purchasers specify the type of tender procedure and the criteria used in the selection.

The organization of the paper is as follows. In the following section, definitions of important terms and concepts are provided. A framework for analysing the role and position of environmental criteria in supplier selection is presented. Furthermore, within the overarching behavioural perspective, two opposite paradigms of organizational decision-making are presented, enabling the development of theoretical propositions about the use of environmental criteria in supplier selection. The next section describes the method used for collecting and screening official tender documents for environmental statements; it also discusses how these statements were analysed in order to assess the actual use of environmental criteria. Then, the paper goes on to present an overview of the use of environmental criteria in each of the analysed purchases. In the subsequent section, these findings are analysed in the light of the aforementioned paradigms of decision-making, leading to the identification of four basic strategies for including environmental criteria, further to implications for practitioners and policy-makers. The paper concludes with theoretical contributions and research limitations.

## 2. Defining GSS and introducing two theoretical paradigms of organizational decision-making

This section begins by defining the terms 'GPP' and 'GSS' and clarifying the difference between them. It then presents the general

supplier selection process and addresses its relationship with environmental criteria. Section 2 concludes by providing a theoretical perspective on organizational decision-making.

### 2.1. GPP and GSS

Supplier selection is a core procurement activity in both the private and public sectors. Procurement concerns not only supplier selection, but also contract management, placing orders, handling delivery, after care, and further supplier development, such as knowledge development and capability development (Cousins et al., 2008). GPP therefore includes more than GSS, but it should be noted that GPP is typically used in a narrow definition, focussing on nearly the same meaning as GSS in the public sector.

The differences between GSS in the public and private sectors are associated with the nature of public and private procurement. Briefly stated, the main distinctive characteristics of public procurement (in contrast to private sector purchasing) are the need to comply with regulations aimed at avoiding discrimination and differential treatment of suppliers, compulsory public announcements of calls for tenders, and using procurement as a tool for government policy (Knight, 2007; New et al., 2002). Public purchasers are not allowed to use environmental criteria that can be regarded as favouring (or excluding) specific suppliers (The European Commission, 2011).

### 2.2. Supplier selection process and environmental criteria

As illustrated in Fig 1, the purchasing and supply management literature describes supplier selection as a multi-stage, multi-criteria problem (Cousins et al., 2008; De Boer et al., 2001). Supplier selection typically starts with the process of identifying needs. Then, purchasers agree on measurement criteria for potential suppliers, and a call for tenders is communicated to potential suppliers. Purchasers make a first selection after reviewing the information submitted by candidate suppliers, usually referred to as the qualification stage. This process may take several rounds, and the final selection is made by evaluating the tenders from a limited number of qualified suppliers, typically based on several criteria. In addition, supplier selection may also include a post-selection evaluation of the supplier's performance (Morton, 2002). The information obtained from a post-selection evaluation may be stored and made available for later use and improvements. Supplier selection clearly involves the typical elements of the organizational decision-making process, such as identification of problems, development of alternatives, and selection of a solution (Mintzberg et al., 1976).

As described in official EU documents (The European Commission, 2004, 2011), environmental requirements and criteria can be included at different stages in the supplier selection process: the specification stage, the qualification stage, and the final selection stage; ultimately, it can also be included as a performance clause in the contract closed with the chosen supplier. Table 1 lists the possible stages and ways of including environmental requirements and criteria in the supplier selection process.

Including environmental criteria in supplier selection is not a straightforward matter in practice. It requires a purchaser to answer several questions: (a) How should environmental criteria

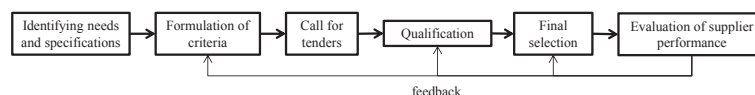


Fig. 1. Supplier selection process (Cousins et al., 2008; De Boer et al., 2001; Morton, 2002).

**Table 1**  
Nature of different requirements and criteria in supplier selection (The European Commission, 2011; Thomson and Jackson, 2007).

Specification requirements	Qualification criteria	Award criteria	Contract clause
Suppliers have to meet	Suppliers have to meet	The more points suppliers meet, the better their score is	Suppliers should follow
Product-specific criteria (including production process specific)	Sorting Criteria related to the supplier's financial and technical ability to perform a contract Exclusion criteria can be included	Ranking Product-specific criteria (including production process specific criteria)	Criteria related to service, work, personnel, disposal and transport

be treated: as independent, “new” criteria or as an extension of an existing criterion such as price and quality? (b) Which environmental aspects should be chosen among the sheer breadth of the set of potential criteria? and (c) Where in the various stages of the supplier selection process should environmental criteria be included? Having to make choices along these three dimensions simultaneously adds to the complexity of GSS.

### 2.3. Two paradigms of organizational decision-making

The forementioned research question, ‘How do public purchasers, seen as organizational decision-makers, deal with the complexity of GSS?’, can be further narrowed to the following: To what extent and in which ways does one see environmental criteria in practice (regarding complexity a and b above)? Do purchasers use all possible stages in the selection process or do they focus more on some stages than others (complexity c above)? Because complexity is central to the discussion of decision-making paradigms (Steinbruner, 1976), the theoretical background of this study can be based on this strand of literature regarding decision-making. From a behavioural perspective on decision-making (Simon, 1957), one would expect that additional cognitive demands and tasks, for example expanding the set of criteria to consider, would force the decision-maker to simplify the decision-making process unless he or she is provided with additional resources to handle this increased complexity (Ashby, 1960). In order to more specifically analyse and characterise the purchaser's approach to handling the increased complexity of GSS, Steinbruner's (1976) distinction is used between two fundamental paradigms of organizational decision-making: the cybernetic paradigm and the analytical paradigm. The cybernetic paradigm employs a rather minimalistic logic in its description of decision-making processes. It does not require the decision-maker to process a great deal of information, to make explicit causal models of how the world works or to trade various goals off against one another (Steinbruner, 1976). It is conservative in the sense that existing, known patterns of solutions are used until they are repeatedly shown to fail. Only then does the decision-maker need to take action and suggest a new pattern of solutions, typically not very different from the previous one (Cyert and March, 1963). The analytical paradigm, however, assumes a much more comprehensive approach. The decision-maker actively seeks and gathers information, constructs formal, causal models of the environment and, based on calculations of alternative options, makes decisions in which multiple goals are compared against each other (Steinbruner, 1976). The decision-maker then chooses the alternative leading to the highest overall utility.

At first glance, the bulk of the literature on GSS seems to adhere to the analytical paradigm rather than the cybernetic paradigm. Igarashi et al. (2013) provide an extensive overview of the GSS literature and conclude that scholars have paid the most attention to development of normative decision models that serve to transform various types of information into a single quantitative score, enabling a perfectly-ordered preference for the various suppliers. ‘Green performance’ is typically traded off for performance on classic supplier selection criteria such as price, quality and delivery (Humphreys

et al., 2006; Kuo et al., 2010). Normative decision models can be said to embed or preserve the added complexity of including criteria in supplier selection, implicitly assuming that the purchaser is able to handle this. The cybernetic paradigm, however, would emphasize minimizing the added complexity of including environmental aspects into the decision-making as much as possible.

All in all, it is proposed that the analytical paradigm would emphasize the use of environmental criteria in the final stage of the selection process, the award stage. In particular, it would evaluate environmental performance against performance in other areas such as price and quality. The cybernetic paradigm, however, would generally simplify and downplay the use of environmental criteria. If included, the decision-maker would avoid explicit trade-offs between environmental performance and other types of performance by limiting environmental evaluation to the early stages of the selection process. The analysis will focus on the extent to which the empirical findings seem to support the dominance of the analytical or the cybernetic paradigm.

### 3. Methods

Existing literature demonstrates two approaches to measuring and examining the state of environmental consideration in public procurement: use of secondary data, i.e., auditing tender documents (Kippo-Edlund et al., 2005; Nissinen et al., 2009) and primary data gathering, i.e., conducting survey questionnaires and/or interviews (Bouwer et al., 2005; Lambert and Solevåg, 2010). While the questionnaire method possibly overstates the environmental consideration, the investigation of tender documents seems to lack a reliable method of analysis, often relying on the subjective classification of ‘greenness’ of tender documents (Prenen, 2008). The methods used in this study aim to provide an objective analysis of environmental criteria in different stages of the procurement process; they also seek to provide a considerably deeper analysis by focussing on how buyers treat environmental criteria. The need for such robust analysis has been pointed out by Testa et al. (2012). Fig. 2 depicts the methods used in this study, while Sections 3.1 and 3.2 provide detailed descriptions of data collection and data analysis, respectively.

#### 3.1. Data collection method

There were two steps in material collection. First, because of its interesting context in GPP, information and communication technology (ICT) equipment was chosen as a focused product group for searching purchase projects. The EU has prioritized this sector in public procurement due to the scope of potential environmental improvements, such as public expenditures, potential impacts on the supply side, example-setting for private and corporate consumers, market availability and economic efficiency (The Commission of the European Communities, 2008). ICT is also one of seven product groups that the Norwegian government has prioritized in an action plan for environmental and social responsibility in public procurement (Norwegian Ministry of the Environment et al., 2007). Following these priorities, a substantial

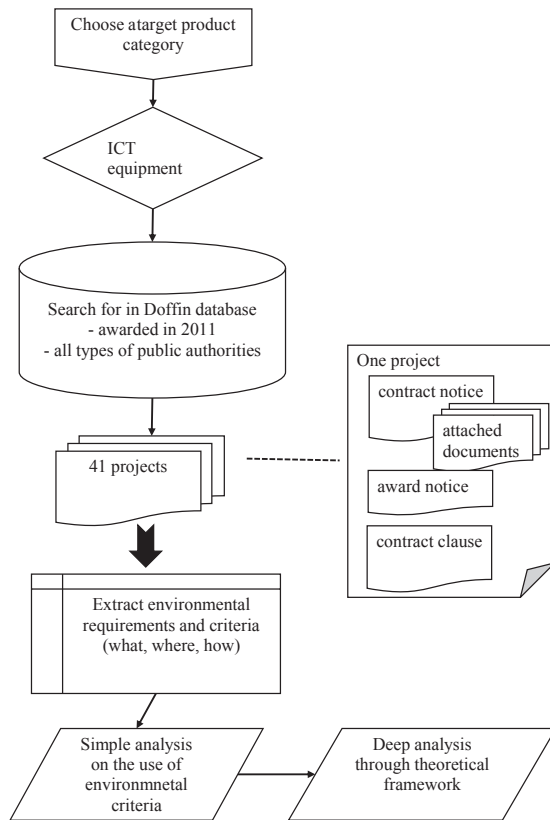


Fig. 2. A graphical presentation of the method flow.

number of different environmental criteria are addressed in the guideline published by the European Commission (The European Commission, 2008). Meanwhile, various eco-labels and national-level guidelines have been produced in countries such as Norway, Sweden and Denmark. Some documents report a relatively high inclusion of environmental criteria in ICT procurement (CEPS and College of Europe (2012); Pettersen and Larsen, 2011). It is worth investigating how decision-makers make demands of suppliers in this climate of increasing information and pressure. ICT equipment exemplifies this context. Hereafter, ICT refers mainly to office ICT equipment, such as computers, monitors, printers, copiers, scanners, faxes, multifunctional printers and projectors.

Once a focused product group was chosen, award notice documents of ICT equipment published in 2011 were searched for in Doffin. From there, the corresponding contract notice documents were tracked, which usually include several attachments and a contract clause. A contract notice document and its award document constituted one project as depicted in Fig. 2. As a result, 41 projects in the ICT group were obtained as material for this analysis. This paper uses *tender document* as a generic term including contract notice documents (call for tenders), attached documents, award notice documents and contract clause documents.

### 3.2. Data analysis method

All types of documents were thoroughly read and examined in order to assess if they included any environmental considerations,

and all environmental requirements or criteria that appeared in the documents were recorded in a matrix. Also noted were, the stages where they appeared (specification, qualification, award and contract clauses), their type (organization-related, product-related, and packaging-related), the award criteria used, and their weights. A pre-compiled list of possible environmental criteria was used (Appendix A), combining the lists of Nissinen et al. (2009), the guidelines published by the Norwegian Agency for Public Management and eGovernment (hereafter referred to as Difi) (Difi, 2008) and the EU guidelines (The European Commission, 2008). This list served as an aid to identifying environmental requirements and criteria. The environmental criteria ranged from environmental management systems and environmental policy to energy use, noise, lengthy warranty and recycling system. 'HSE (health, safety and environment of workers) compliance to regulations' was not considered as environmental criteria. Still, some criteria related to human health are included, such as 'flame retardant' (which can damage human health), as indicated in the EU guideline. It should also be noted that the main aim was to comprehensively examine criteria that explicitly placed environmental aspects under the label of 'environmental criteria'; implicit environmental criteria that are appeared under other labels were recorded within a limited amount of time and resources.

When it comes to the type of environmental criteria, they are typically structured as relating to the products/services being purchased or to the supplier that is producing or providing them (Igarashi et al., 2013). Product-related criteria include, for example, having a recycling system for products' end of life, a guarantee of repair parts during a certain period, or energy-saving compliance in accordance with the Energy Star program. Organization-related criteria include having an environmental policy and certification of environmental management systems. In addition, a category for packaging-related criteria is considered, which typically involves a recycling or reuse system for packaging.

The first author examined all of the projects. To confirm the consistency of the research, 5 out of the 41 projects were examined separately by the third author.

## 4. Results

This section provides pure findings from the examination of the tender documents. It also includes a detailed account of how environmental criteria appeared in the supplier selection process.

### 4.1. Environmental criteria included in the projects

Of the total 41 ICT projects in 2011, 32 projects (78%) had some form of environmental requirements or criteria. Each project has different ways of including environmental criteria in terms of the amount of and places for environmental criteria (see Appendix B for detail). Types of environmental criteria also vary. According to our classification of environmental criteria, the environmental management system was remarkably dominant in the organization-related criteria (see Appendix A). On the other hand, energy saving and recycling/reuse systems for end-of-life products were most frequently used as product-related criteria. Recycling/reuse systems for packaging was a typical packaging-related criterion.

Environmental criteria recommended in guidelines published by the EU or Difi are frequently used at all stages. Overall, 39% (66 out of 171) of the environmental criteria used are based on the EU and Difi criteria, as indicated in Appendix A. The common use of such criteria seems to be a response to the call for national standards and template for GPP; Michelsen and de Boer (2009) found that 70% of Norwegian municipalities welcomed such initiatives.

Further, cluster analysis was performed for the purpose of grouping the 41 projects into several categories. The raw matrix of 41 projects were organized based on the existence or nonexistence of organizational- and product-related criteria in four stages in order to reduce variables in the cluster analysis. Then, cluster analysis was conducted by using three effectual variables (product-related criteria in specification, organization-related criteria in qualification and product-related criteria in the award stage). Contract clause was not used as a variable for cluster analysis because obligations in contract clause do not work as a selection criterion. Four clusters were obtained as a result of this analysis. Table 2 illustrates the grouping and the characteristics of the four groups. The first group reflected environmental criteria mainly in specification, while the second group displayed no environmental criteria. The third group typically included environmental criteria both in specification and qualification or only in qualification, and the fourth group was characterized by environmental criteria in the award stage as well as other stages.

#### 4.2. Environmental award criteria

Fig. 3 presents the award criteria, the average weight given to them, the range of the weight, and the frequency. Price (purchasing price), followed by quality, was the most considered criterion in the award stage both in terms of weight and frequency. Five projects adopted the lowest price as the award criteria, giving price 100% weight. Environmental criteria appeared more frequently than delivery, service and maintenance, and cost, but its weight was lower. When included, the weight given to environment ranged from 5% to 20%.

In short, environmental criteria were the third most frequent award criteria after price and quality, but the average weight was lower than all other award criteria.

#### 4.3. Implicit environmental criteria

The analysis identified some cases where statements could indicate environmental aspects implicitly even though they were not necessarily addressed as environmental criteria. For example, ICT33 contains specific environmental criteria in the award criteria under the label of 'quality', including the recycling system, energy consumption and the certification of the environmental management system. This labelling system might be logical, given that scholars have pointed out the close parallels between environmental management and quality management (e.g., Lamming and Hampson (1996)). ICT35 requires a returning scheme for lease machines and cartridges in service demands in the specification stage, a demand that could also have an environmental impact. There are obviously some criteria that embody two aspects -

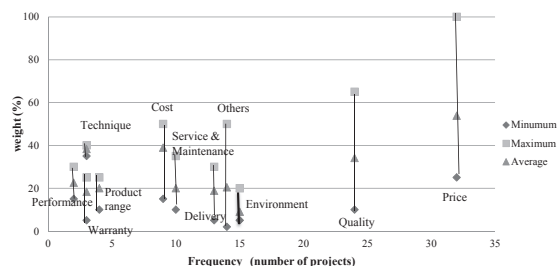


Fig. 3. Criteria in the award stage and the weight given to them. Note: 'Others' includes user-friendliness, competencies, administrative condition, etc.

environment and quality or environment and service. Examples of such criteria are energy consumption, noise, product guarantee and supply of repair parts for a certain period.

Costs could also be regarded as environmental criteria since life cycle costs or running costs often positively correlate with environmental impacts for the life cycle or the operation. The audit of tender documents was unable to reveal whether or not purchasers intended to implement better environmental performance by checking on the life cycle or running costs.

## 5. Analysis using the theoretical framework

Based on the findings presented in the previous section, the research question is now addressed: 'How do public purchasers, seen as organizational decision-makers, deal with the complexity of GSS?' The main framework for this analysis involves the characteristics of the two paradigms of decision-making described in Section 2. One crucial point is whether or not the trade-off between the conventional aspects and the environmental aspect is manifested. Another point involves the extent to which adjustments from conventional supplier selection to GSS were observed.

#### 5.1. Four strategies for dealing with increased complexity

Analysing the findings with the cybernetic and analytical paradigms, four basic strategies that a purchaser can use for dealing with the increased complexity of GSS are derived.

**Strategy 1.** Ignoring the green dimension as an explicit criterion ('Ignore')

In Table 2, group 2 shows that in 9 out of 41 purchasing projects, any explicit reference to environmental criteria was absent. The cybernetic paradigm would explain this finding by considering the

Table 2  
Grouping of the projects and the characteristics of the groups.

Group	Projects	Types of environmental criteria/requirement
Group 1	ICT1, 6, 20, 30, 33, 35, 37	Specification
Group 2	ICT8, 9, 17, 19, 21, 22, 23, 27, 31, 40	No environmental criteria
Group 3	ICT5, 7, 29, 39,	Specification + Qualification
	ICT12, 14, 15, 24, 26	Qualification
Group 4	ICT2, 3, 16, 18, 25, 32, 36	Specification + Award
	ICT28, 34, 41	Award
	ICT4, 10, 11, 13, 38	Specification + Qualification + Award

actual pressure on addressing the environment low, meaning the continuance of only conventional criteria was perceived as sufficient. So long as none of the organization's essential variables fall outside the critical range, there is no need to make any changes (Ashby, 1960). From the point of view of the analytical paradigm, this evidence is more difficult to explain, as it assumes that a purchaser is interested in considering the possible consequences of choosing supplier A over supplier B in terms of environmental performance.

**Strategy 2.** Incorporating environmental performance under existing criteria and requirements ('Incorporate')

As described in Section 4.3, environmental issues were added to existing criteria, such as 'quality' or 'service' in a few cases. Seen from the cybernetic paradigm, this action can be seen as making minor, local adjustments to the existing standard operating procedure. Thus, it recognizes the need to make changes in the current decision-making process as a result of increasing external pressure. Still, in line with the cybernetic paradigm (Steinbruner, 1976), local adjustments will first be tried, resulting in extending existing criteria, such as quality, service or cost, rather than introducing an independent, new criterion. The advantage is that, in many ways, the decision-making process remains the same with a minimal additional effort required from the purchaser. In the case that 'quality' or 'service' is traded off directly for 'price', one could argue that this scenario would represent a form of 'value integration' as proposed by the analytical paradigm. Still, because the environmental criterion is already embedded in another criterion, its 'value' is not made explicit and is not traded off independently for the other criteria. Hence, the observations are more difficult to align with the analytical paradigm.

**Strategy 3.** Environmental criteria as mandatory requirements, avoiding trade-offs ('Insist')

A rather large set of cases in our data show that environmental criteria are used in the specification and/or qualification stage (group 1 and 3 in Table 2) without having environmental award criteria. This strategy also seems to fit well with the cybernetic paradigm because it clearly avoids trading environmental performance for other criteria, such as price or quality, allowing environmental criteria to work as qualifiers. It implies a typical 'satisficing' approach (Simon, 1957) in which alternatives that exceed a certain minimum aspiration level are accepted, without a more precise mutual and relative comparison. Therefore, the evaluation of environmental performance is decoupled from possible subsequent evaluations of other criteria. In contrast to the previous two strategies, the change in the decision-making process is more profound, as explicit environmental criteria are added to the set of conventional criteria at the specification and/or qualification stage. However, because environmental criteria are lacking in the final award stage, and green performance is not traded off for performance on other criteria, the analytical paradigm does not seem to fit as well as the cybernetic paradigm.

**Strategy 4.** Trading off environmental performance for other criteria ('Integrate')

In this strategy, one or more explicit environmental criteria are applied in the final award stage, and traded off for other award criteria, such as price and quality (group 4 in Table 2). This observation is consistent with 'value integration', and hence, this strategy is most reminiscent of the analytical paradigm.

This strategy can be further divided into two sub-strategies. One sub-strategy is to give low weight to the environmental award criteria, for example, 5–10%; hence, despite a product's or service's good environmental performance, it has little integrated value. In

this case, the relevance of environmental award criteria for making a difference between two suppliers is questionable. The other sub-strategy is to give more weight, for example, 15–20%, to the environmental criteria. This weight is significant in terms of sending a possible signal to the market place (The Commission of the European Communities, 2008). Only a few projects were found adopting the latter sub-strategy.

Consolidating out analyses, it seems that in a given procurement project, purchasers first choose, intentionally or unintentionally, either to ignore (Strategy 1) or to refer to environmental criteria in some way. When selecting the latter choice, Strategy 2, 3, or 4 can be used alone or in combination (Fig. 4). Some examples of using multiple strategies in combination include ICT33 and ICT35, which use Strategy 2 and 3, and ICT2, ICT10 and ICT25, which use Strategy 3 and 4.

## 5.2. Reflections on two selected issues in using the strategies

This section addresses two specific issues observed in the findings related to the use of some of the strategies above. The first issue is related to Strategy 2 'Incorporate'. As stated in Section 4.3, environmental requirements/criteria are sometimes presented under the label of other categories, such as quality, service and cost. If such cases become more common, it will be more difficult for both purchasers and suppliers to become aware of environmental considerations in tender documents. The Difi guidelines (2008) advise that '...the environment should be a separate weighting criterion, not concealed as a part of something else, such as quality.' It would be easier for supervising organizations to monitor the inclusion of environmental criteria if they were addressed as an independent variable. However, from a behavioural decision-making perspective, it is a simpler way for both purchasers and suppliers to treat environmental criteria within a conventional set of criteria because a minor adjustments are required.

The second issue is related to Strategy 4 and is concerned with the relatively low weight assigned to the environmental criteria. The weight given to environmental criteria in this study ranged from 5 to 20%. Existing studies report 5–20% (Parikka-Alhola et al., 2006) and a maximum of 10% (Varnäs et al., 2009). The Difi guidelines (2008) state '...weighting should be set to at least 20% ...' In addition, 'environmental award criteria should, altogether, account for at least 10–15% of the total points available.' (The European Commission, 2011). Therefore, the weight given to the environmental award criteria seems unsatisfactory in terms of a political recommendation. Parikka-Alhola et al. (2006) argue that the weight range may appear to reflect a low preference for environmental aspects but that it still sends a signal to the suppliers that the environmental soundness of a product can influence decision-making. Kippo-Edlund et al. (2005) emphasize the significance of environmental criteria in making the suppliers aware of high environmental project standards. On the other hand, a study by Michelsen and de Boer (2009) questions the effect of

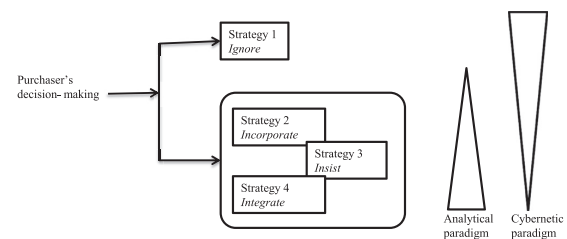


Fig. 4. Strategies for dealing with the complexity of green supplier selection.

environmental criteria on award decisions. Another study points out that no information has been collected on the role of environmental criteria in the assignment of contracts (Testa et al., 2012). All in all, it seems difficult to ascertain how much weight is appropriate for a given procurement project, and policy-makers and purchasers often struggle to balance conventional procurement goals and non-conventional goals, as pointed out by Cogburn and Rahm (2005).

### 5.3. Implications for practitioners and policy-makers

This analysis provides purchasers in the public sector important information as a benchmark. They will gain an overview of which types of environmental criteria are stated in practice throughout the different stages in the supplier selection process and how much weight is typically attached to them.

Purchasers need to be aware of the complexity of GSS as well as possible approaches to dealing with this complexity. To do so, it is essential that purchasers understand of the nature and role of criteria at different supplier selection stages. Needless to say, ignoring environmental aspects is hardly a sustainable strategy. Applying mandatory environmental requirements/criteria in specification/qualification may make sense as a starting point. If purchasers raise the mandatory level according to the technological and market conditions, it will increase suppliers' willingness to improve the environmental performance of their operations and products.

It is also important that policy-makers acknowledge challenges related to the complexity of GSS and develop a broader set of policies that take into account the four strategies that purchasers tend to use in GSS. These results suggest that in spite of the existing GPP policies, laws and directives, some purchasers still consider ignoring the use of environmental criteria a viable strategy. As proposed in this paper, rather than merely looking at this situation as a violation of rules and regulations, the cybernetic interpretation of this strategy is that the 'green pressure' on purchasers and their organizations has to exceed a certain threshold before it evokes a significant reaction (Ashby, 1960). In current public procurement practices, there seems to be a tension between policy-makers and practitioners concerning how to present environmental criteria to suppliers in tender documents and how to assign the amount of weight that can and should be attached to environmental award criteria. Previous studies (Michelsen and de Boer, 2009; Testa et al., 2012) indicate a lack of knowledge among public purchasers, and based on those findings it may be unrealistic to expect purchasers to be able to carry out direct comparisons between environmental and economic performance for each and every purchase. The required variety for such a task, in terms of time, knowledge and economic resources may simply not be available. Increasing the purchasers' variety by providing them with more time and knowledge will certainly help but categorically requiring direct trade-off's (with a minimum weight of 20% for environmental criteria) for each purchase is too narrow a policy. GPP policies should probably focus more on assisting purchasers in giving up 'ignore' as a strategy and improving their use of the 'incorporate' and 'insist' strategies.

Given that purchasers frequently use the strategy of applying environmental criteria in specification and/or qualification stage, developing meaningful criteria could be more effective at least in the near future. Policy-makers can promote functional criteria rather than developing specified environmental criteria (Rizzi et al., 2014). They should also encourage purchasers to gradually raise the mandatory performance levels using the 'incorporate' and especially 'insist' strategies in accordance with developments in a given industry or product market, thus ensuring the development of green procurement.

## 6. Conclusions

This study audited environmental statements in tender documents, which were retrieved from a Norwegian public procurement database. It further analysed the supplier selection processes with environmental criteria from the perspective of behavioural decision-making. By discussing actual GPP practices, the paper has contributed to the sustainable development literature, more specifically to the stream of literature on GPP. The assessment has found that environmental criteria are addressed in 78% of the tender processes of ICT equipment in the form of specific types of environmental requirements or criteria. Specification is the most prominent stage where environmental requirements are stated, both in terms of frequency and the total number of requirements. Environmental award criteria also appear in quite a few projects. It is the third most frequent award criteria following the two classical criteria of price and quality. Still, in most of cases, environmental award criteria seem to have little influence on final decisions in supplier selection, judging from the weight given to them; this finding supports previous studies. The analysis also revealed that the suggested environmental requirements/criteria from the national and multilateral agencies are often applied in tender documents.

This paper contributes to the purchasing and organization behavioural literature, too. It suggests that purchasers consciously or unconsciously use four strategies in GSS based on two decision-making paradigms: Ignore, Incorporate, Insist and Integrate. This set of strategies seems more compatible with a bounded rationality and cybernetic view of decision-making compared to an analytic view. A direct and genuine trade-off between green performance and other classical purchasing criteria (Integrate) will be limited to those cases where purchasers have access to the required cognitive ability to match the complexity posed when directly comparing environmental and economic performance. Purchasers are likely to use environmental criteria as qualifiers early in the selection process (Insist) or as part of other existing criteria (Incorporate). These strategies represent effective ways of matching the solutions available to a public purchaser with the complexity posed by the decision-making task.

Although this study is limited to a certain type of purchase item in one country, we would claim that our findings regarding the four strategies for dealing with GSS complexity, can be applied to GPP in other European countries. Like Norway, most European countries follow the EU legal framework on public procurement. Looking at other products might provide similar or different findings, and surely, the findings of this study will be a point of departure for a wider scope of research.

For further understanding of purchasers' cognitive limitations and their perceptions regarding such limitations, more in-depth research is needed into how purchasers incorporate environmental criteria into classic criteria. Data need to be obtained directly from purchasers by interviews in order to examine such aspects.

Based on the analysis of our data, one cannot deduce why in most cases in our sample a relatively low weight was assigned to the environmental criteria. Previous studies, however, such as Michelsen and de Boer (2009) and Testa et al. (2012), indicate a clear lack of training and competence development for public purchasers in the area of sustainability and environmental issues. In the former study, for example, less than 6% of the purchasers participating in the study felt that they had sufficient competence to formulate environmental demands and evaluate the information received from suppliers. An interesting proposition for future research is to investigate if the low weight assigned to environmental criteria may be related to the uncertainty about how to compare environmental performance with economic performance.

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**Appendix A. List of specific environmental criteria.**

Classification	Code	Type of environmental criterion	References	Frequency	
Organization specific	O1	Environmental management measures (EMM)	Ni	4	
	O2	Environmental policy	Ni	4	
	O3	Environmental program	Ni		
	O4	EMS (Environmental management system)	Ni	14	
	O5	EMM of subcontractors	Ni	4	
	O6	Environmental training and knowledge	Ni		
	O7	Waste, energy and water data (of the firm)	Ni	1	
	OD	Other organization related criteria, defined		7	
	Product specific	P1	Energy use	Ni, EU	5
		P2	Energy saving in accordance with Energy Star	Difi, EU	16
P3		Emissions to air or water	Ni	1	
P4		Noise	N, Difi, EU	8	
P5		Material amount	Ni		
P6		Recycled material	Ni		
P7		Material choice	Ni		
P8		Chemical content	Ni		
P9		Recycling/reuse systems	Ni	23	
P10		Recyclability	Ni		
P11		LCA-based EPD	Ni		
P12		EU ecolabel or -criteria	Ni		
P13		Other ecolabels or -criteria	Ni	6	
P14		Environmental impact in production process	Ni	1	
P15		Memory slot	Difi	4	
P16		Display	Difi	2	
P17		Long lifetime	EU	2	
P18		Lengthy warranty	Ni		
P19		Guarantee of repair parts for at least three years	Difi, EU	6	
P20		Guarantee of repair parts for at least five years	Difi	2	
P21		Guarantee of operation parts at least five years	Difi	4	
P22		No flame retardant substances (R45, 46, 60, 61)	Difi, EU	4	
P23		Handling of superfluous equipment	Difi	3	
P24		Self-declaration form of a new model	Difi	2	
P25		Right to ask for ecolabel documentation	Difi	5	
P26		Documentation for the user and the operation managers	Difi	2	
P27		The use of mercury in LCD monitor backlighting	EU		
P28		Ease of disassembly	EU		
P29		Duplexing function	EU	1	
P30		Availability of spare parts	EU		
PD	Other product related criteria, defined		18		
PM	Packaging material	Ni			

(continued)

Classification	Code	Type of environmental criterion	References	Frequency
Packaging related	PR	Packaging recycling/reuse systems	Ni, Difi	21
	PP	Recyclable packaging	Ni	
	ND	Other criteria, not well defined		1

In the column 'References', Ni stands for Nissinen et al. (2009), Difi for Difi (2008), and EU for the European Commission (2008).

**Appendix B. Environmental criteria in 41 ICT projects**

	Specification	Qualification	Award criteria	Contract clause
ICT1	P2	PR, P9		
ICT2	P2, P4, P15, P17, P19		P9, P13, P20	P23, P24, P25, P26
ICT3	P23, PD		P1	
ICT4	P2	O2	P9, P13, PR	
ICT5	P9, PR, PD,	O4		
ICT6	P2, P4, P9, P15, P16, P21, P22			
ICT7	P2, P4, P16, P19	O4		
ICT8				P25, PR
ICT9				
ICT10	O4, P9, PD	O1, O2	O2, O4, O5, P9, PR, PD	
ICT11	P2, P4, P15, P19, P25	O4	P2, P4, P15, P19, P25	
ICT12		OD		
ICT13		O4	ND	
ICT14		O2		
ICT15		O7		
ICT16	P9, P19, P22		P9, P19, P22	
ICT17				
ICT18	P9, PR		P9, P13, P17	OD, O1
ICT19				
ICT20	O1, P9, P21, PR		(O1, P9, P21, PR)	
ICT21				
ICT22				
ICT23				
ICT24		O4		
ICT25	O4, O5, P2, P9, PR		O4, O5, P2, P9, PR	
ICT26		O4, PR		PR
ICT27				
ICT28			P4, P20	
ICT29	P9, P9	O4		
ICT30	P2, P9, P21			
ICT31				
ICT32	P2, PR, PD, PD,		P2, PR, PD, PD,	P2, PR, PD, PD, PD, P9, P9
ICT33	P1, P2, P9		(O4, P1, P2, P9)	
ICT34			PD	PR
ICT35	P2, P22, PR, (P9)			
ICT36	P1, P2, P3, P4, P21, P29	P9, PR	P1, P4	PR, OD
ICT37	P1, P9, P13, P14, PR, PD			
ICT38	PD	OD, OD, OD	PD	OD
ICT39	P13, PD	O4, O5, P13, PR		P23, P24, P25, P26, PR, PD
ICT40				
ICT41			O4, P9, PD	

Notes: 1. The codes for environmental criteria correspond to those in Appendix A. 2. When more than two of the same codes appear in the same column, it means that more than two different criteria are stated; still, they are categorized into the same code. For example, in ICT 29, there are two P9, and each concerns the return scheme for the toner and the machines. 3. Criteria in brackets are implicit environmental criteria.

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Paper III

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Paper IV

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