Decision making on capital investments in the process industry; why substantial energy savings are missed

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SUMMARY

In light of political and environmental developments, there is an urgent need for reduction of energy consumption. Still the opportunities for energy savings in industrial processes appear to be highly underutilized. Acknowledging the relevance of the supply chain, this study focuses on decision making processes related to investments in energy-intensive equipment. The aim is to increase our understanding on the role of energy efficiency in decision making and the role of different value chain partners herein.

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INTRODUCTION

Research on sustainability and sustainable operations has developed over the past decades with specific attention to the business case for sustainable business (Golicic and Smith, 2013; Margolis and Walsh, 2003; Orlitzky et al., 2003). Because of the widely recognized need for sustainable conduct (Hart, 1995; Hart and Dowell, 2010), the challenge has changed from "whether" to act in a sustainable way to *"how"* to act in a sustainable way (Kleindorfer et al., 2005; Pagell and Wu, 2009).

One of these *"how"* questions is about the urgent need for energy efficiency improvements; Governments set targets[1] for businesses as major energy consumers and industry's current challenge is to make progress at a high pace and to change drastically in order to meet those targets. There are already examples of promising energy efficiency enhancing initiatives, but the opportunities for energy savings in industrial processes appear to be highly underutilized (Sorrell et al., 2011).

In the energy literature we find indications about barriers to industrial energy efficiency within organizations (Sorrell et al., 2011). However, important parts of the energy savings challenge are bound to be beyond a single organization's reach and boundaries. In other words, viewing this challenge from a supply management perspective might yield relevant insights to deepen our understanding how to enhance energy efficiency. Recent practitioner

[1] E.g. http://ec.europa.eu/clima/policies/package/index_en.htm

studies also suggest that energy efficiency potential is highly dependent on what happens in the supply chain (NAP, 2010).

In this study, we focus on decision making processes related to investments in energy-intensive equipment, aiming to increase our understanding on the role of energy efficiency in decision making. Our main research questions are:

1. How does the energy efficiency criterion impact decision-making processes on energy-intensive capital equipment?
2. How can the impact of the energy efficiency criterion be increased in investment decisions involving multiple stakeholders throughout the supply chain?

We specifically study the dyad between suppliers of energy intensive equipment on the one hand and industrial buyers on the other hand. Our research project is part of the top sector approach of the Dutch Government, primarily aimed at process industries. This positioning enables us to collaborate with multiple stakeholders with relevant know-how and expertise on issues related to energy savings in such industries. Collaboration with the partners in our Dutch top sector project enables the exploration of new research territory in companies which have made recent investments in energy-intensive equipment which is relevant to the industry (Guide and Van Wassenhove, 2007).

THEORETICAL BACKGROUND

Industrial Energy Efficiency

There is an emerging body of literature on energy efficiency drivers and barriers, especially in the energy-related literature. In line with research on the adoption of new management practices like TQM, Six Sigma and ERP systems, Blass et al. (2014) conclude that top management is an important factor in decisions to adopt energy-efficient initiatives. More specifically, they find that especially top operations managers, as opposed to top managers without an operational role, have a positive effect on the adoption of such initiatives.

In another study Anderson and Newell (2004) found that adoption rates are higher for energy-efficiency projects with shorter payback periods, lower costs, increased annual savings, higher energy prices, and greater energy conservation.

Related to these findings, there remain a number of hurdles organizations need to overcome in their efforts to improve the energy efficiency of their operations. Anderson and Newell (2004) observed a variety of reasons for not adopting energy-efficient projects, with a vast majority falling in the category of economic reasons. The gist of the respondents' reasoning is that the non-adopted project have an unattractive balance between final costs and benefits.

These economic considerations also play an important role in the taxonomy of barriers to energy efficiency proposed by Sorrell et al. (2011), as summarized in Table 1.

Table 1: Taxonomy of barriers to energy efficiency

Barrier	**Examples**
Risk	• Business risk • Technical risk
Imperfect information	• Lack of data on own organization's energy use • Lack of information on energy efficiency opportunities
Hidden costs	• Overhead costs of energy management • Cost of data collection, identifying opportunities etc • Cost of production disruptions
Access to capital	• Internal capital budgeting procedures • Availability of capital
Split incentives	• Equipment purchasers not accountable for energy use (and the associated savings)
Bounded rationality	• Constraints on time, attention an ability to process relevant information

Source: Based on Sorrell et al. (2011), Tables 2.3 and 5.3

Based on Table 1, one can conclude that a diverse set of barriers may hinder organizations in their efforts to adopt energy efficiency increasing projects. Sorrell et al. (2011) also conclude that the mix of barriers is typically contingent on individual technologies and industries.
Moreover, from the perspective that human behavior and decision making processes itself heavily affect investment and purchasing outcomes (Carter et al., 2007), it can be concluded that hardly attention has been paid to those processes. More research is warranted to the *process* of investments itself to obtain more in-depth insights into strategic decision making associated with investments in energy intensive equipment. In this context, there have been calls for specific attention for such investments in the process industry (NAP, 2010).

Strategic decision making process
In the past decades various strands of literature, including strategic management and organization theory, generated a lot of research on the topic of strategic decision-making processes. Arguably one of the most influential papers in this domain is that of Mintzberg et al. (1976). This seminal paper is based on a field study of 25 strategic decision process and proposing a framework as a basic structure underlying such predominantly ill-structured processes. This framework comprises of three main phases (identification, development, selection), in which various internal or interrupts may require decision makers to return to earlier phases. The interplay between phases and interrupts results in complex, often quite erratic patterns of decision making.
For the purpose of this paper, it is especially interesting to zoom in on a subset of four strategic decisions dealing with the purchasing of sophisticated technological equipment. Mintzberg et al. (1976) label this type of decisions as 'modified search' and observe an extensive cycling in especially the development phase of the decision making process.

Moreover, it was observed that such modified search decisions had to be authorized at three successive hierarchical levels.

Numerous studies have been executed since Mintzberg et al. (1976), all aiming to further increase our knowledge on various elements of strategic decision making processes. In a review of this literature, Eisenhardt and Zbaracki (1992) concluded that strategic decision makers typically have to deal with conflicting objectives, partly and restricted cognitive capabilities. Following up on this, Schwenk (1995) argues that these key characteristics of strategic decision making processes, conflicts and bounded rationality, are closely related to the impact of biases on the quality of the resulting decisions. More specifically, Schwenk (1995, p 477) specified the following relevant types of biases: causal attributions, escalating commitment and recollection. Illustrative for the causal attribution bias is the tendency of decision makers to attribute good performance to their own actions, while attributing poor results to external factors. Escalating commitment in essence boils down to a tendency to keep increasing commitment to a failing project, which ultimately may lead to big strategic failures. Finally, biases in recollection imply that decision makers often have distorted memories of past strategic decisions, which in turn restrict their ability to learn from the past.

Schwenk (1995, p 485) considers the intersection of such biases and competitive strategic decision making processes as one with high research potential. An example of the relevance of this interface is provided in a study of Dean and Sharfman (1996) on the effectiveness of strategic decision making, based on an analysis of 52 decisions in 24 companies. In essence this study shows that decision processes matter in terms of decision making effectiveness. Managers can exploit such processes to influence the rate of success of their decisions. More specifically, Dean and Sharfman (1996) found support for their hypotheses that procedural rationality of decision processes is positively related to decision effectiveness, whereas a negative relation is found for political behavior. In combination these findings reconfirm the potential impact of biases on strategic decision making processes. Procedural rationality can be seen as an effort to reduce the negative impact of biases, for example by investing substantially in data collection and analysis, and by actively deploying analytical decision making techniques. On the other hand, political behavior, for example encompassing the pursuit of own interests and the use of power-play, can actually be seen as illustrative for the negative impact of biases.

Behavioral supply chain management

The potential impact of biases on decision-making has also attracted research in the supply management domain, as part of the emerging body of literature on behavioral supply chain management (Katsikopoulos and Gigerenzer, 2013; Kaufmann et al., 2010, 2012a; Kaufmann et al., 2012b; Kaufmann et al., 2014; Kull et al., 2014; Riedl et al., 2013; Thomas et al., 2011). Based on a comprehensive review of the relevant literature, Carter et al. (2007) proposed a taxonomy of supply management decision biases, as summarized in Table 2.

Table 2: Taxonomy of supply management decision biases

Barrier	**Description**
Availability cognition	A decision maker judges information which is more easily recalled from memory as being more probable.
Base rate	Base rate data are ignored or devalued in favor of other, less relevant data.
Presentation	The mode, mixture, order, or scale within a presentation influences the perceived value of data, thus leading to systematic errors in judgment.
Control illusion	A sequence of random events or non-representative samples can be mistaken as an essential characteristic of a process, leading to unrealistic confidence in judgment.
Output evaluation	The degree to which an event would have been predicted is usually overestimated in retrospect, or when failure is associated with bad luck and success with the abilities of the decision maker.
Commitment	An inappropriate tendency to continue an undertaking once a decision regarding an investment in money, time, or effort has been made.
Confirmatory	Decision makers seek confirmatory evidence and fail to search for disconfirming information for desired outcomes or strongly held values.
Persistence	An alternative is chosen simply because it has been chosen in the past, implying the search for new options is limited.
Reference point	A decision maker's judgment of uncertain quantities is biased in the direction of a relevant comparison value or reference point.

Source: Based on Carter et al. (2007)

Supplier selection is one of the important decisions that play a major role in supply chain management. This selection decision can be approached in different ways. Dual process theory emphasizes intuition and rationality as contrasting approaches that affect behavior and decision making regarding sourcing (Kaufmann et al., 2014). The use of rationalized procedures has been found to enhance supplier selection decisions (Kaufmann et al., 2012b; Riedl et al., 2013) and cost performance (Kaufmann et al., 2014) in contrast with more intuitive approaches to decisions made by sourcing teams (Kaufmann et al., 2014). Kaufmann et al. (2014) indicate that experience based, intuitive approaches may rather enhance performance which is not directly related to costs and both approaches could be complementary. Research and analysis of trade-offs between high degrees of rationality (optimizing) and more intuitive, time saving, procedures (satisficing) could help executives in their decisions regarding supply management (Carter et al., 2007).
Kaufmann et al. (2010) found that those decisions are enhanced when knowledgeable decision makers are involved and organizational structures that hold decision makers accountable for their decisions, so that detailed documentation of all decisions is in place and decision makers know they have to explain. This again links to a rationalized, rather than an intuitive approach. In our study we aim to analyze to what extent decision making around energy efficiency has been rationalized.

METHODOLOGY

Multiple retrospective case studies (Barratt et al., 2011; Langley and Abdallah, 2011; Yin, 2009) form the empirical part of this research project. Case studies in general "primarily use contextually rich data from bounded real-world settings to investigate a focused phenomenon" (Barratt et al., 2011) . Sampling of more than one case enables cross-case comparison and adds confidence in findings (Miles and Huberman, 1994). We aim to realize six case studies.
Case studies are selected based on the following criteria:

- It concerns recent investments, purchased between 2012-2015
- Energy intensive investments by businesses ('profit sector')
- Capital investments between € 1M and € 10M

The unit of analysis is the capital equipment investment decision making process, involving various actors in both the purchasing and supplying organization. This focus enables a fine-grained analysis at the micro-organizational level on the role and impact of these various actors in the choice for more or less energy efficient equipment. In doing so, insights from process research studies study (Langley et al., 2013) will be instrumental given the temporal nature of our unit of analysis.
Various data collection methods will be applied in order to enable triangulation. Major sources of information are: (i) semi-structured interviews at both the buying and supplying organizations, and (ii) archival data from internal and external publications. An interview protocol (see Appendix for a summary of the interview guideline) is developed for the semi-structured interviews to enhance reliability of the case studies (Eisenhardt, 1989; Yin, 2009). These interviews will take place with people from different functional areas. This provides multiple approaches to the same phenomena and the possibility of triangulation, which enhances the reduction of social desirability biases (Podsakoff et al., 2003). All interviews will be transcribed and coded with Maxqda software. Data analysis will take place of the recorded interviews and archival data through double coding by two researchers from recordings and documents.

PRELIMINARY RESULTS

In total this research is based on six cases of recent capital investment projects in the Dutch process industry. Currently, data have been collected for two cases. One case (A) involves a recent investment of a multinational in the fast-moving goods industry, the other (B) is situated at a multinational producing products purchased by facilities services of their customers.
It is interesting to analyze how potential decision making biases (see Table 2) have been dealt with in our cases. Carter et al (2007) mentioned an examination of the moderating effects of de-biasing efforts in supply management decision making as a fruitful, albeit cumbersome area for future research. Table 3 contains some initial findings on such efforts for one of the cases (B) based on the interviews executed so far, emphasizing that the data collection has not been completed yet.
In case B, in line with both the *availability cognition bias* and the *persistence bias* it would have been tempting to involve only known suppliers for this specific investment. Still, the decision making process also involved a supplier unknown to company B and actually this supplier won the bid. When motivating this outcome, company B's manager of the engineering department remarked that *"this (new) supplier was willing to jointly adapt their*

standard concept, whereas competing suppliers were less willing to do so". This outcome was even more remarkable since the selected supplier had the most expensive solution, implying that company B managed to overcome a quite common *reference point bias* in the purchasing domain, i.e. opting for the lowest price solution.

Table 3: Dealing with supply management decision biases in cases

Barrier	**Case B**
Availability cognition	New suppliers were explicitly involved in the process, actually a new supplier won the bid.
Base rate	New supplier applied a sort of 'greenfield' approach for the new equipment.
Presentation	-
Control illusion	-
Output evaluation	-
Commitment	Various business functions participated in the decision making process, but purchasing department was not involved at all.
Confirmatory	Strict procedure for ranking alternatives, completed my multiple staff members.
Persistence	A new supplier won the bid.
Reference point	In the end, the supplier with the most expensive solution was selected.

The supplier selection process in case B also provides a good illustration of overcoming a *base rate bias*. The supply market for the required equipment is quite conservative, yet the new supplier proactively proposed a new energy recovery system. One of company B's engineers observed that *"this (new) supplier started at zero, taking a piece of paper to figure out what this type of equipment had to do"*.

Company B deploys a very strict procedure for ranking alternatives for this specific investment decision, enabling them to minimize the *confirmatory bias.* Since this procedure involves a team of about ten members, representing different relevant expertise areas, this approach also has the potential to address the *commitment bias*. Company B's manager of the engineering department states that "*each team member individually completes the checklist, but it is quite surprising that typically 80 or 90% arrives at the same final score".*

Still, one factor potentially undermining the efforts to avoid commitment bias, is the fact that company B's purchasing department was not involved in the decision making process at all. Actually both respondents were clear on this as illustrated by the following quotes:

"With all due respect, our purchasing people are not knowledgeable about this. In investment projects like this technical people talk to technical people. We try to avoid a too commercial approach" (Engineer Company B)

"No, no purchasers. I am very confident in stating that all Engineering investments do not involve our purchasing department. They primarily do the manufacturing supplies and packaging." (Manager engineering department Company B)

Actually these quotes from company B's engineering staff can be seen as a bias themselves, predominantly of the confirmatory type. Apparently there is a strongly held belief within this engineering department that their purchasing colleagues are primarily, or even solely, interested in commercial aspects of equipment investment decisions.

CONCLUDING REMARKS

This research is currently in the data collection phase. The first cases have started and others are about to start. We include some case companies that are leading in the area of Corporate Social Responsibility (CSR). This exemplar status does, however, not automatically imply that green or social criteria play a decisive role in all investment decisions. In our research, we ideally strive to analyze two of those companies' recent decision-making processes on substantial equipment investments. In one of these processes energy efficiency is one of the key decision criteria, whereas in the other this criterion only plays a marginal role. By interviewing key involved stakeholders at both the purchasing and supplying organization, we aim to unravel the mechanisms behind these different outcomes. These insights will improve our understanding of drivers and barriers on the road to more energy efficient industrial processes.

Industrial energy efficiency is a highly relevant societal theme to which those cases are aimed to contribute. Both from a societal perspective and from an academic perspective the question why seemingly feasible energy-efficient solutions are not selected in decisions around process technology and the role of the value chain are intriguing.

REFERENCES

Anderson, S.T., Newell, R.G., 2004. Information programs for technology adoption: the case of energy-efficiency audits. Resource and Energy Economics 26, 27-50.

Barratt, M., Choi, T.Y., Li, M., 2011. Qualitative case studies in operations management: Trends, research outcomes, and future research implications. Journal of Operations Management 29, 329-342.

Blass, V., Corbett, C.J., Delmas, M.A., Muthulingam, S., 2014. Top management and the adoption of energy efficiency practices: Evidence from small and medium-sized manufacturing firms in the US. Energy 65, 560-571.

Carter, C.R., Kaufmann, L., Michel, A., 2007. Behavioral supply management: a taxonomy of judgment and decision-making biases. International Journal of Physical Distribution & Logistics Management 37, 631-669.

Dean, J.W., Sharfman, M.P., 1996. Does decision process matter? A study of strategic decision-making effectiveness. Academy of Management Journal 39, 368-392.

Eisenhardt, K.M., 1989. Building Theories From Case Study Research. The Academy of Management Review 14, 532-550.

Eisenhardt, K.M., Zbaracki, M.J., 1992. Strategic decision making. Strategic Management Journal 13, 17-37.

Golicic, S.L., Smith, C.D., 2013. A Meta-Analysis of Environmentally Sustainable Supply Chain Management Practices and Firm Performance. Journal of Supply Chain Management 49, 78-95.

Guide, V.D.R., Van Wassenhove, L.N., 2007. Dancing with the Devil: Partnering with Industry but Publishing in Academia. Decision Sciences 38, 531-546.
Hart, S.L., 1995. A natural-resource-based view of the firm. Academy of Management. The Academy of Management Review 20, 986-1014.
Hart, S.L., Dowell, G., 2010. A Natural-Resource-Based View of the Firm: Fifteen Years After. Journal of Management 37, 1464-1479.
Katsikopoulos, K.V., Gigerenzer, G., 2013. Behavioral operations management: A blind spot and a research program. Journal of Supply Chain Management 49, 3-7.
Kaufmann, L., Carter, C.R., Buhrmann, C., 2010. Debiasing the supplier selection decision: a taxonomy and conceptualization. International Journal of Physical Distribution & Logistics Management 40, 792-821.
Kaufmann, L., Carter, C.R., Buhrmann, C., 2012a. The impact of individual debiasing efforts on financial decision effectiveness in the supplier selection process. International Journal of Physical Distribution & Logistics Management 42, 411-433.
Kaufmann, L., Kreft, S., Ehrgott, M., Reimann, F., 2012b. Rationality in supplier selection decisions: The effect of the buyer's national task environment. Journal of Purchasing and Supply Management 18, 76-91.
Kaufmann, L., Meschnig, G., Reimann, F., 2014. Rational and intuitive decision-making in sourcing teams: Effects on decision outcomes. Journal of Purchasing and Supply Management 20, 104-112.
Kleindorfer, P.R., Singhal, K., van Wassenhove, L.N., 2005. Sustainable Operations Management. Production and Operations Management 14, 482-492.
Kull, T.J., Oke, A., Dooley, K.J., 2014. Supplier Selection Behavior Under Uncertainty: Contextual and Cognitive Effects on Risk Perception and Choice. Decision Sciences 45, 467-505.
Langley, A., Abdallah, C., 2011. Templates and turns in qualitative studies of strategy and management. Research Methodology in Strategy and Management 6, 201-235.
Langley, A., Smallman, C., Tsoukas, H., Van de Ven, A.H., 2013. Process studies of change in organization and management: unveiling temporality, activity, and flow. Academy of Management Journal 56, 1-13.
Margolis, J.D., Walsh, J.P., 2003. Misery Loves Companies: Rethinking Social Initiatives by Business. Administrative Science Quarterly 48, 268-305.
Miles, M.B., Huberman, A.M., 1994. Qualitative data analysis : an expanded sourcebook. Sage Publications, Thousand Oaks, CA.
Mintzberg, H., Raisinghani, D., Theoret, A., 1976. The structure of" unstructured" decision processes. Administrative Science Quarterly, 246-275.
NAP, 2010. Process Industy and Energy Savings. Van de Ridder Druk & Print, Nijkerk, the Netherlands.
Orlitzky, M., Schmidt, F.L., Rynes, S.L., 2003. Corporate social and financial performance: A meta-analysis. Organization Studies 24, 403-441.
Pagell, M., Wu, Z., 2009. Building a more complete theory of sustainable supply chain management using case studies of 10 exemplars. Journal of Supply Chain Management 45, 37-56.
Podsakoff, P.M., MacKenzie, S.B., Lee, J.-Y., Podsakoff, N.P., 2003. Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies. Journal of Applied Psychology 88, 879-903.
Riedl, D.F., Kaufmann, L., Zimmermann, C., Perols, J.L., 2013. Reducing uncertainty in supplier selection decisions: Antecedents and outcomes of procedural rationality. Journal of Operations Management 31, 24-36.
Schwenk, C.R., 1995. Strategic decision making. Journal of Management 21, 471-493.
Sorrell, S., Mallett, A., Nye, S., 2011. Barriers to industrial energy efficiency: A literature review. United Nations Industrial Development Organization (UNIDO).
Thomas, R.W., Fugate, B.S., Koukova, N.T., 2011. COPING WITH TIME PRESSURE AND KNOWLEDGE SHARING IN BUYER–SUPPLIER RELATIONSHIPS. Journal of Supply Chain Management 47, 22-42.
Yin, R.K., 2009. Case study research : design and methods. Sage Publications, Thousand Oaks, CA.

APPENDIX: GUIDELINE SEMI STRUCTURED INTERVIEWS

Main question

Which factors in the (social) environment of employees and teams influence the importance of energy efficiency (EE) as criterion in capital investment decisions, both at the end user and supplier side?

Case introduction

- Technology, investment budget
- Main aim (e.g. improving existing process or complete new process)
- Respondent's role in the case

About the decision-making process

- Project description, including important milestones
- Ownership/financing
- Composition of purchasing/design team
- Suppliers involved (including attention for potential barriers in supplier contacts)
- Specifications (content and process)
- Selection procedure (e.g. use of shortlist, criteria weights)
- Use of protocols
- Reflection on team process (with specific attention for the role of EE)
- Evaluation, including any lessons learned for future decisions

Potential bottlenecks/barriers

- Time available for this project?
- Opportunities to explore alternatives?
- Dealing with time pressure?
- Pricing/business case of this project?
- ……..

EE in team & organization

- To what extent is this case representative concerning the importance of EE in your organization?
- In general, what is the role/impact of EE in your organization's strategy?
- Is there a link with the activities of a sustainability office (if your organization has one)?
- More specifically, what is the role/impact of EE in your team?

Looking back …

What would you advise other decision makers facing similar capital investments?