CBI CENTRE FOR BUSINESS INNOVATION

Center for Business Innovation Working Paper Series

No. 20

Formulating Problems for Commercializing New Technologies

The Case of Greening

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June, 2010

WORKING PAPER **SERIES**

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ABSTRACT Starting with problems as the unit of analysis, this paper analyzes how a firm identifies and solves environmental problems and how this is translated into new environmental offerings. The paper shows that firms can employ parallel and unrelated problem formulation and solving processes for commercializing environmental technology. We illustrate this empirically by analyzing a multinational mechanical engineering corporation that developed and launched what they describe as a 'green product line' to help customers to reduce their CO_2 emissions. This paper contributes to the management literature by providing an empirical study of how firms formulate and solve environmental problems and how the reformulation into an environmental problem changes the initial value proposition into a more generic proposition, thereby increasing the profit potential though the generation of new applications and increased usage.

Key words: Environmental innovation, green, problem formulation, problem solving, value creation

INTRODUCTION

In the past decades research has shown that the economy is unsustainable from an environmental point of view (Stern et al., 2006; IPCC, 2007). It has been argued that a sustainable economy requires a reduction in environmental impact by a factor of between 4 and 10, depending on the application (Robért et al., 2000). The magnitude of the problem means that it is unlikely to be resolved only by the actions taken by consumers or firms serving users directly. Although demand for environmental sustainability is generated primarily downstream, the changes required would likely affect and potentially hurt upstream actors that are unprepared in terms of shifting demand. The complexity of the problem means that it also is unlikely to be solved by regulation and will require the cooperation of several parties (Porter and Van der Linde, 1995; cf. Ostrom, 1990). Thus, since the beginning of this century, the market has been shifting from a purely regulatory approach towards an upgrading of greening on the corporate agenda (Porter and Kramer, 2006).

The drivers for companies to become “greener” and develop green offerings comprise a range of factors. First, as population and economic growth increase the pressure on, e.g., waste, water, and consumption of fossil fuels and raw materials, the economics of scarce resources are calling for new effective solutions with respect to the environment and energy. Thus, green initiatives often are directly related to the opportunity to decrease costs and increase efficiency (WBCSD, 2000). Second, employee morale and a socially responsible image for the firm are important drivers of corporate sustainability initiatives (Keeble et al., 2005; Davies, 1960), and many firms are incorporating energy and carbon dioxide saving into their corporate social responsibility policies. Third, regulation is an important factor in corporate initiatives for becoming greener (Porter and van der Linde, 1995). This includes regulation aimed at internalizing negative externalities but also subsidies for certain technologies, and deregulation of certain markets. For example, in recent years, the energy market has undergone extensive deregulation, which has called for investment in this industry. In addition, political pressure for sustainable development implies the possibility of stricter regulation in the future. Fourth, there is increased demand from both consumers (World Values Survey Association, 2008) and firms (Keeble et al., 2005) for environmentally friendly products, services and production processes. Fifth, and partly as a result of the above drivers, many firms see major opportunities for differentiation (Ottman, 1998; Grant, 2007) and other types of competitive advantage from involvement in environmentally friendly innovations (Sharma and Vredenburg, 1998).

There are several definitions of what are broadly termed environmental or eco innovations. Currently there is major policy interest in developing rigorous classification and indicators for these terms, e.g., at EU and OECD levels (Foxon and Andersen, 2009), and concepts often described as “environmental technologies” or “clean technologies (cleantech)”. In the Environmental Technology Action Plan of the EU Commission, environmental technologies are defined as “all technologies whose use is less environmentally harmful than relevant alternatives. They include technologies to manage pollution (e.g. air pollution control, waste management), less polluting and less resource-intensive products and services (e.g. fuel cells) and ways to manage resources more efficiently (e.g. water supply, energy-saving technologies)” (EU Com, IP/04/117). Similarly, the related concept of clean technologies is defined by the Cleantech Group as products, services, and processes intended to provide superior performance at lower cost, while greatly reducing or eliminating negative ecological impact and at the same time improving the productive and responsible use of natural resources.

However, as the environmental agenda has evolved so has our understanding of environmental innovation and eco-innovation (Foxon and Andersen, 2009). The more preventive and integrated policy approach to environmental issues has changed the focus from end-of the pipe solutions to more front-end products that address market needs. Thus, environmental innovation and eco-innovation embrace all technologies, products, solutions, processes, services, and new management and business methods that are more environmentally friendly than their relevant alternatives, and at the same time add economic value through lower costs or improved profitability. Hence, environmental innovations reduce net environmental impacts while creating economic value.

There is growing interest in environmental considerations from firms (Keeble et al., 2005). However, to date, research has focused largely on demarcation (what is or is not green) and the drivers of corporate sustainability initiatives (why firms should care). Little work has been done on "how" commercial environmental offerings are developed in established firms and how these are formulated for solving environmental problems.

From a problem-solving perspective, for the firm, an opportunity corresponds to a valuable problem-solution pair (Hsieh et al., 2007). In fact it can be argued that a crucial task in innovation activity is to formulate and solve valuable problems (Baer et al., 2008). Thus, the terminologies of problem and solution can be utilized to describe and analyze the discovery of situations that will generate value, such as in the case of the development of new environmental offerings. There is only sparse knowledge about the process involved in the formulation and resolution by firms of problems related to "greening", and no published work specifically analyzes the phenomenon from a problem-solving perspective. The questions we should ask are: *how do firms formulate and solve green problems; and how is this problem-solving process transformed into new green offerings?*

This paper explores the problem solving process of formulating and solving green problems and how it affects value creation and rent generation through the commercializing of new technologies. We show how solving a customer problem can reveal new problems that need to be identified and solved, and can result in valuable green problem formulation. More specifically, we show that a problem solving process, consisting of problem formulation and resolution, corresponding to the commercialization of a new technology by a firm, can be performed through two parallel and unrelated processes, and that a reformulation into an environmental problem can make the initial value proposition into a more generic proposition, thereby increasing the profit potential through the generation of new applications and increased usage.

The present paper shows how the development of a particular green offering progresses through four stages: 1) initial narrow problem formulation, based on information from the customer; 2) the decomposition of and efforts to solve the problem; 3) minor and major reformulations of the problem; and 4) identification of opportunities enabling the resolution of a larger array of problems through this particular reformulation of the problem. This is an area on which prior research lack knowledge, and should constitute a contribution to work on iterative models of problem-solving processes (e.g. Mintzberg, 1976).

Research on decision making tells us that organizations' problem solving is not always rational or iterative, and that socio-political, cognitive and discursive dynamics frequently influence the constitution of events as "problems" (Eisenhardt and Zbaracki, 1992). We also know that when identifying problems serendipity can occur, that solutions may create problems, and that solutions/answers may look for problems (Cohen et al., 1972; Popper, 1997). While, we acknowledge these and other alternative mechanism for identifying problems, our focus is not to develop a theory of how organizational problems are identified in general. Rather, our focus is on the formulation and solution of green problems for commercializing new technologies, and what and how problem identification mechanisms affect that commercializing process.

Empirically we study ALFA[I], a Swedish multinational corporation (MNC), which introduced energy efficient solutions engineered to reduce frictional movements by up to 40 percent on previous bearings solutions.

The paper is organized as follows. The next section reviews the literature on problem formulation and problem solving. This is followed by the methods and an explorative case study of a mechanical engineering MNC that reformulated its problem formulation based on a given solution. The paper ends with a discussion and conclusion.

LITERATURE

Recent theorizing in the knowledge based theory of the firm – the problem-solving perspective – argues that discovering an opportunity involves two distinct activities (Nickerson and Zenger, 2004; Hsieh, et al., 2007): identifying and selecting the problems to be solved and identifying valuable solutions through organized search or sheer luck. In other words, pairing of valuable problems-solutions constitutes an opportunity within the problem-solving perspective (Hsieh et al., 2007). The problem-solution terminology can be utilized in order to explain the discovery of situations that may generate value.

Many would argue that the manager's job is to solve problems. Of principal concern for managers is that problems need to be identified, defined, evaluated, and prioritized in terms of urgency and importance, before they can embark on the task of deciding which resources

[I] The name of the corporation has been disguised for reasons of confidentiality.

to devote to solving them and how they should be solved. These are non-trivial issues for managers because the situation often demands that these processes are performed without any well-defined theory or prior experience. Perhaps the single most important aspect of the problem solving process is formulating the problem because this, in large part, determines the subsequent course of action (Lyles, 1981). However, although the task of problem formulation is critical to managers' decision-making responsibilities, the reality is that managers rarely fully understand the sources of their problems (Pounds, 1969). A second aspect often emphasized in literature is the importance of decomposing the problem into more manageable sub-problems (Simon, 1962).

Nickerson and Zenger (2004) emphasize that managers need to focus on problems and not on creating new knowledge or capability per se, because it is very difficult simply to choose which new knowledge or which capability to acquire. So, even though the problem solving perspective (Nickerson and Zenger, 2004) shares the assumption of the knowledge based theory of the firm (Kogut and Zander, 1992; Conner and Prahalad, 1996) that the key managerial objective is to create valuable new knowledge (Nickerson et al., 2007), managers should focus on formulating and selecting valuable problems rather than trying to create new knowledge. If valuable problems are resolved, they are likely to result in desirable new knowledge that will reveal new means to convert inputs into valuable outputs. Therefore, the problem solving process cannot be separated from knowledge creation. It is only by reference to a previous state of knowledge that a problem can be explained or formulated, and it is only by creating knowledge that a problem can be solved (Landry, 1995).

Problems can be explained broadly as the differences between some perceived existing situation and some perceived desired situation (Pounds, 1969). For managers this can include everything from financial, human resources, marketing, strategic to innovation-related problems. For example, when a firm develops new products or services it needs to formulate and solve a multitude of innovation-related problems (Cyert and March, 1963; March and Simon, (1958) 1993). Innovation-related problems are the problems that firms face in the innovation process and are a subset of the wider class of firm organizational problems (Terwiesch and Xu, 2008; von Hippel, 1994). The primary focus of this paper is environmental (green) problems with a secondary focus on innovation-related problems; it explores how firms formulate and solve environmental problems and how these actions are translated into new environmental offerings (i.e. bringing an environmental technology to market).

To define the concept of a "green problem", we start with the general problem definition proposed by Pounds (1969), that is, that a problem is defined as the difference between a perceived state of affairs and an imagined future preferred state of affairs. A "green problem" is a subset of this concept in which the preferred state of affairs is more aligned to the conditions of a sustainable society. In this paper, we use the four[II] system conditions outlined by the natural step foundation and related research (e.g. Robért et al., 2002; Holmberg, 1995) to define the system conditions of a sustainable society. We choose this definition because it is fairly concrete and is supported by a stream of peer-reviewed and published research. However, it is not our intent to take a particular stance in the debate over what is regarded as "green". We believe that the arguments in this paper could have been developed equally well on the basis of other definitions of "green" that consider the case-products energy-saving properties to be beneficial from an environmental perspective.

[II] Since our focus in this paper is on only the environmental aspects of new offers, it relates only to the first three system conditions in Robért et al. (2000) i.e. "In order for society to be sustainable, nature's functions and diversity are not systematically subject to: I. increasing concentrations of substances extracted from the Earth's crust; II. increasing concentrations of substances produced by society; III. physical impoverishment by over-harvesting or other forms of ecosystem manipulation" (Robert et al, 2000).

The problem solving process is an important topic for several disciplines, including strategic planning (e.g. Mitroff and Mason, 1980), strategic decision making (e.g. Nutt, 1984), the behavioral theory of the firm (e.g. Cyert and March, 1963), the social practice view of organizations (e.g. Brown and Duguid, 2001), and organizational knowledge creation theory (e.g. Nonaka, 1994). However, problem formulation has attracted less attention from management scholars (Getzels, 1979; Baer et al., 2008). Most have focused on identifying methods for solving already well-defined problems, and in many instances, theories assume that problem formulation is a given in the problem solving process. Even the behavioral theory of the firm, which views organizations as information-processing devices that formulate and solve problems, focuses mainly on organizations as problem-solving devices and does not deal with how problems are formulated in the first place. Most other theories of the firm suffer from similar shortcomings (Baer et al., 2008). Still, the nature of how the problem is formulated becomes important for the rest of the problem solving process. Consider, e.g., the delayed elevator problem presented by Ackoff (1969), in which case an office building manager is confronted with complaints about the elevators in the building: If the problem is perceived as related to the technical elevator system, some new system components might be proposed. However, if the problem is perceived as one of people being intolerant about having to wait for the elevator, one solution might be to install mirrors or notice boards near to the elevators to divert them.

Hence, in order to create valuable solutions to problems, managers must first identify the problem they need to address. The challenge is in identifying the “right” problem: managers frequently solve the “wrong” problem by adopting a problem formulation that is either too narrow or inappropriate (Mitroff and Featheringham, 1974; Baer et al., 2008). If the latter occurs, this implies an error in the formulation of the problem; typically referred to as an error of the third kind (Mitroff and Turoff, 1974). This may mean that the assumptions made as to its causes are incorrect. It has been emphasized, and shown, even that managers may skip or abbreviate the activity of problem formulation (Mintzberg et al., 1976; Nutt, 1984). Lyles (1981) found that in 25 out of 33 cases U.S. companies that went through a problem-solving process had to return to problem formulation because managers either had defined the problem inappropriately or had skipped the problem formulation stage altogether. The advantage of cycling back to problem formulation is that it allows a reassessment of the problem, while the related costs are loss of opportunities, time, money, and morale (Lyles, 1981). One explanation for this lack of attention to problem formulation may be that managers have been trained to become decision-makers in the sense of being problem solvers – not problem formulators.

It should be noted that most research on problem formulation is based implicitly on the so-called phase-theorem of problem solving (Lipshitz and Bar-Ilan, 1996; Witte, 1972). The phase-theorem describes the assumed tendency for the problem-solving process to progress through a sequence of events from problem sensing to problem solving. For example, Simon (1960) describes these phases as “Intelligence”, “Design” and “Choice”, while Pounds (1969) splits the process into eight phases: “Choose a model”, “Compare it to reality”, “Identify differences”, “Select a difference”, “Consider operators”, “Evaluate consequences”, “Select an operator” and “Execute”. In later research which adds nuance to the models of problem solving, the role of iteration is frequently acknowledged and explored (e.g. Lyles, 1981; Cowan, 1986). As already mentioned, Mintzberg et al. (1976) found that decision makers frequently skipped one or several phases in the proposed model, and also often returned to earlier phases (e.g. problem formulation) late in the process. However, the general tendency of certain phases to occur more often in the early or late stages of the process seem to be a ubiquitous assumption.

Not all problems are valuable for firms, and managers should not try to select problems from which the firm has little chance of capturing value. Nickerson and Zenger (2004) argue that, once the problem is identified, the value of a particular problem depends on two factors. These factors are: 1) the values of the possible solutions; and 2) the costs of discovering a particularly valuable solution. Based on the problem selected, the manager's task is to organize a search for solutions that optimize the likelihood, speed, and cost of discovery of a valuable solution (Nickerson and Zenger, 2004). The search for solutions is uncertain, however, and to identify a valuable solution depends on the trials undertaken (where each trial reflects a unique combination of knowledge sets). Hence, problems differ in their optimal solution search form, where the choice of problems reflects an assessment of the expected value of potential solutions and an assessment of the firm's ability to profit from high-value solutions. Therefore, in choosing the problems, managers choose an unknown set of potential solutions, but once chosen the task is to identify the knowledge needed and to maximize the probability of discovering valuable solutions.

To advance our knowledge on how firms formulate green problems for commercializing new technologies we now turn to the case of a manufacturing company that launched a complete product line under the premise of solving a green problem.

METHOD

This paper builds on an explorative case study (Eisenhardt, 1989; Yin, 1994) to explain how a firm identifies and solves environmental problems. The case study approach was chosen to provide an in-depth illustration of a social phenomenon, i.e. problem formulation and problem solving in product development (Yin, 1994), lacking in the prior research. While case studies are superior for creating an understanding of empirical phenomena and generating novel theory (Eisenhardt, 1989), they are inherently limited in terms of their generalizability (Yin, 1994). This limitation in the present paper is reduced to some extent in that the case is linked to work on problem solving perspective.

Data were collected from interviews, marketing information such as product brochures and the corporate website, trade press, and legal documents. The first set of interviews was unstructured and was followed by subsequent semi-structured interviews.

Initial data collection was aimed at exploring the role of environmental considerations in the new product development of several large corporations, including ALFA, which is the case study described in this paper. Interviewees were managers, typically at or close to executive level (e.g. chief technical officers, business development directors, and vice presidents). Nine interviews were conducted at ALFA. The study extended over three months, with a final follow up interview four months later in order to clarify certain points. The case study for the present study was identified from the initial interviews and involved semi-structured follow up interviews with people directly involved in the problem solving and development process. The final semi-structured confirmatory interview was based on a questionnaire explicitly using the concepts of problem formulation and solution, served to confirm and revise our interpretations of the development of the problem formulations process for the energy efficient (E2) case.

Data collection and analysis were primarily conducted according to what Miles and Huberman (1994) refer to as a “prestructured case”, i.e. a sequence of events describing the case was identified and mapped out before the end of the data collection. In our case, initial sequence mapping was done after several interviews. The mapped sequence was further tested and revised against the final interview. The interview parts relating to the E2 case were transcribed but not formally coded according to any preset coding scheme. Rather, they were used to verify the final case description against the original data.

Reliability was achieved by triangulating the different data sources, including the various perspectives expressed by the various interviewees, and public documents. What was described in the answers to our questions about particular problem formulations was repeatedly in line with our understanding of the concepts. Our arguments regarding internal validity are based primarily on the fit with the previous theory – parsimony – and the logical coherence of our arguments (cf. Pfeffer, 1982). Ecological validity is deemed to be high because data collection was made directly in the "ecology" (i.e. the subjects were interviewed in their place of work, and were involved in the processes they described) and the original model was derived inductively from these data. However, the artificial situation of an interview might have influenced the data, for example in the shape of "espoused theories" (Argyris, 1994) being aired. We tried to correct for this by systematically asking for examples and posing overlapping questions regarding general principles of behavior expressed by the interviewees (e.g. organizational values regarding environmental performance).

CASE

The case study explores a problem solving process conducted by ALFA, a Swedish MNC, which resulted in the introduction of its new family of more energy efficient bearing solutions for the automotive industry, referred to within the firm as part of "the green line". The bearings were engineered and manufactured to reduce power loss by up to 40 percent beyond the already efficient, standard bearing solution, and helping customers reduce their energy consumption and CO_2 emissions. Although the product line described encompasses several applications, the case story begins with, and primarily focuses on, the development of a transmission system solution that converted torque and speed from a rotating power source to another device, which is a common application in vehicle gearboxes. But, to us start at the beginning…

In 2005 a German car manufacturer, a customer of ALFA's automotive division, consulted ALFA about a problem. The customer was searching for a low friction solution, with certain performance dimensions, for a transmission setup. ALFA initially saw this as a business opportunity to design and sell a solution. However, after estimating the costs involved in the search for a solution, ALFA decided against committing the resources required to find a solution. In other words, ALFA did not consider it a valuable problem.

One year later, in 2006, ALFA's automotive division was contacted by a supplier to the automotive industry, which had a similar problem to the one posed by the German car manufacturer in 2005. This customer had decomposed the problem into different tasks. In particular, it had been defined by the customer as focused on achieving a given degree of stiffness in the automotive supplier's application – again a transmission system – in addition to the more general problem of power loss. Worth emphasizing here is that the technical challenge was quite substantial, as suggested by the fact that the customer had already tried to find a solution using its usual supplier of bearing solutions, but since this had been unsuccessful, the customer had turned to ALFA.

Again ALFA recognized the business opportunity and this time decided to attempt to solve the problem. The small development team set up in ALFA realized that the solution was not just a single bearing arrangement, but rather involved a "unit concept" – a solution consisting of several bearing types in a preassembled unit – to achieve more stiffness into the arrangement. ALFA developed the solution, which they referred to as the unit concept. An important part of the process leading to this solution consisted of further decomposition of the problem specified by the customer. In particular the recognition of one particular sub problem: One “position” of the intended bearing arrangement, according to one engineering manager, was “quite over designed". The solution was to downsize that position.

ALFA then sold this solution to the customer. Its commercialization was considered a success. It is important that, at the time of that first sale, another problem which was addressed by the solution has been identified by the team that had it: Power loss and energy waste. However, the value of a solution to this problem was not validated by the customer until much later. In order to follow the chronological order of the problem formulation and solving process, we need to understand a parallel problem formulation process in a different part of ALFA.

In 2005 and 2006, simultaneous with the development of the unit concept at ALFA, European fuel efficiency regulation was high on the agenda for own equipment manufacturers in the automotive sector. In summer 2005, the European Commission had issued a high profile Proposal for a Council Directive on Passenger Car Related Taxes (COM(2005) 261), which was approved by the European Parliament, with amendments, in 2006 (although not finally passed until 2009).[III]

[III] After approval from the European Parliament, the Council reached only partial agreement (ec.europa.eu/prelex, 2009-12-22) and discussions ensued. The resulting legislation was finally passed on April 23, 2009 (Regulation (EC) No 443/2009).

As a result of these events, in 2005 and 2006, ALFA's automotive division, including the solution development team, had identified a new potential valuable customer problem: increased fuel efficiency. The rationale was the close connection between fuel consumption and CO_2 emissions in modern internal combustion engines. The development team immediately redefined the fuel efficiency problem as one of reduced power loss and friction in the transmission and consequently within the unit concept already developed. In other words, they identified an additional problem that was solved by the already developed solution. This then was an additional benefit that could be delivered by the same solution.

Although the environmental problem had been identified at this stage – it was considered only a minor part of the larger set of problems addressed by the solution. Originally, the focus of the problem formulation was less on fuel efficiency than later was the case, and the major customer problem the solution was initially aimed at involved technical problems in terms of heat generation, stiffness and efficiency. Thus, in terms of any formalized value proposition at the time, the environmental problem could have been ignored. In addition, there were other benefits from the solution identified, such as easy assembly, but they did not figure largely in terms of the bigger picture in this story.

Consequently, the offer provided the solution to the two problems of 1) not enough stiffness and 2) poor fuel efficiency. The solution was valued by the first buying customer and the deal was considered a success for the automotive division. ALFA had developed a "completely new bearing unit", which also addressed an additional problem not initially identified, which, as we will see, was strategically important as it enabled ALFA to identify several new applications for the same solution.

In 2006 – and more especially in 2007 – the automotive division at ALFA (along with its customer industry) was increasingly looking at the general problem of power loss in vehicles. In Europe, this was being driven in part by regulation. In the course of its investigations, the automotive division at ALFA identified a large set of potential problems related to power loss that could be resolved by solutions similar in principle to the one developed in early 2006, i.e., the unit concept developed for car transmission systems. As a result, development of several variations of the "unit concept" commenced.

In the case of many of the applications, the problem formulations and solutions were very similar to the original ones, and basically were copies. In other cases major parts of the original solution were applicable to the solution to the new problem. The consequent development projects in the automotive division of ALFA ran in 2007 and finished in terms of new products in 2008. The projects involved several separate teams of engineers in the automotive division but were coordinated by the original core team of four people – two managers and two developers – who used their internal networks to orchestrate the projects' resources. During the development of these solutions, understanding of – and subsequently formulations of – the valuable customer problems being resolved increasingly began to include environmental aspects.

The first time that environmental aspects of a resolved customer problem were actively communicated externally was in 2007. The automotive division had developed one of their more successful follow-up products, the internally famous hybrid-pinion unit. ALFA brought up the customer value from solving the environmental problem early on in discussions with customers, and it "was quite easily accepted". For subsequent solutions, the environmental aspects of the problems were made clear to customers by ALFA to achieve confirmation of their relevance to the environmental problem.

An important complement to the solutions developed at that time was a piece of advanced modeling software developed by ALFA, which allows ALFA to estimate savings on fuel, and CO_2-emissions, from a combination of ALFA solutions in complex systems, such as vehicles. This software was referred to in several of the interviews as an important factor for communicating to the customer the value of the problems solved. One interviewee recounted a sales meeting at a customer where ALFA had presented the savings from use of the product in terms of friction. The customer seemed positive, but asked for numbers more relevant to his own firm: "You can tell me a lot about friction, but in the end it is the CO_2 or the fuel that counts". As already mentioned, these sales meetings were an important tool for ALFA managers to validate that the fuel efficiency/CO_2-problem identified was valued by their customers.

Although communicated externally on a customer-by-customer basis in 2007, the first time that the environmental aspects of the problems solved were formulated formally along the lines currently exploited, was in early 2008. Previous to this, the responsible division at ALFA had used the environmental benefits of the solution to communicate its extra value to customers identified as having some variant of the original problems of power loss, heat generation and lack of stiffness in the arrangement. Ultimately, CO_2-savings became part of the core problem-formulation and consequently a means to identify new customers.

This change began when the original development team wanted to communicate the value of its solutions to a broader audience and focused on a regular conference on transmission systems scheduled for autumn 2008 in Berlin. Their presentation material – slides, photographs – were submitted in May 2008. The original development team contacted the marketing and communication team in the automotive division of ALFA for support. The marketing and communication team was already working on a campaign related to a generally formulated environmental problem in industry, initiated at the corporate level. The contact led to extensive work on the value proposition – the valuable customer problems that had been solved – including and emphasizing the environmental problems (partly) solved by the solutions. The work on the value proposition was organized between the original development team of four and the marketing and communication team. This was done in 2008, shortly after the marketing and communication team was introduced to the new solutions. The work on the value proposition was extensive and soon came to include all the business units in the automotive division and several days of joint workshops. This work was closely related to and included preparations for a large marketing campaign in 2008.

The marketing campaign originally was not about the projects discussed in this paper. The marketing and communications team in ALFA's automotive division were not privy to these projects before the contact from the responsible engineering manager in early 2008 when he was preparing the presentation for the transmission conference in Berlin. Nevertheless, the campaign's general goal from the start was to communicate the value of ALFA as a solution provider with competence in the area of energy efficiency, since the environmental problem had been identified as strategic by the highest levels in ALFA. The campaign was "huge" by the standards of ALFA's automotive division. And these new solutions were a nice fit with the planned marketing campaign and were quickly integrated into it. Thus, in the 2008 marketing campaign the environmental aspects of the problems solved by the new solutions were communicated externally and widely.

When the campaign was launched, the solutions were marketed based on the same value proposition as applies currently. They are branded as E2 or energy efficient, and are listed as one of the 12 main product categories on the ALFA website.[IV] The solutions are available for a wide range of important customer applications and marketed with an emphasis on their environmental sustainability. The E2 series is differentiated by and marketed on its high energy efficiency. The solutions can achieve smaller power loss than most, if not all, comparable bearing arrangements. In terms of the trade-off, buyers looking for bearing solutions often take several technical performance attributes into consideration, depending on the application. These performance attributes typically include noise, friction, life, and the geometry and carrying capacity per bearing size. It should be noted that although the E2 solutions have improved performance significantly in terms of the friction and power loss attributes, this comes sometimes at the cost of rebalancing among some of the other performance attributes, e.g. carrying capacity.

The environmental problem addressed by the E2 solutions is the energy wasted due to avoidable friction and power loss. Thus, E2 is a solution to an environmental problem that is application specific. The problem is "environmental" in the sense that its solution helps to alleviate some of the system conditions of a sustainable society (Robért et al., 2000). In the case of the energy produced by the combustion of fossil fuels, the breaking of the first system condition will be alleviated in part by the use of energy efficient solutions. In somewhat more practical terms, this means reducing CO_2 emissions that could cause climate change. For car manufacturers, the E2 products enable the production of more fuel efficient cars, resulting in lower total operational costs for customers and lower future penalties based on CO_2 regulation (e.g. the EU Regulation (EC) No 443/2009).

[IV] However, not all of the products carrying the E2 brand are based on the solution described here.

To summarize, the process leading to the current “green line” was initiated by a specific customer request. The first time the problem was identified, it was not solved. When the problem had been decomposed, and focused on one performance attribute (stiffness), it was presented to ALFA managers a year later, was recognized as a valuable problem and was eventually solved. However, the process involving ALFA’s search for additional attractive problem-solution pairs interacted with an unrelated simultaneous process affecting ALFA’s customers, which led to the identification and formulation of another type of problem addressed by the same solution. The problems of fuel efficiency and CO_2-emissions were quickly decomposed into problems related to friction and power loss. Although not initially recognized as very important, as ALFA managers searched for more and more applications for the original customized solution, the areas of fuel efficiency and CO2-emmissions became more prominent. Current offers based on the original customized solution are branded as “energy efficient” (E2), are referred to in the firm as “the green [product] line” and are marketed under descriptions incorporating the terms “global energy consumption” and “CO_2 emissions” (ALFA, 2009). The identification and formulation of the environmental problem addressed helped ALFA find seemingly unrelated applications for the originally customized solution, such as an improved wheel bearing solution. It is clear that this helped ALFA scale up the number of applications to which the original solution would apply. The identification and later the formulation of the environmental problem addressed clearly affect the value propositions for the related products and ALFA’s own view of the customer value they create. In summary, they affected how an originally customized solution is marketed, and increased the number of customers to target. The major events the development process of relevance to this paper are outlined in Table 1.

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DISCUSSION AND CONCLUSION

The starting point for this paper was a simple empirical question: how do firms formulate and solve green problems and how is this problem-solving process transformed into new green offerings? In the introduction we discussed several obvious reasons for developing green offerings including internal and external branding, cost and eco-efficiency, and facing competitors. However, the existing research does not address the role of formulating and solving environmental or green problems. We have tried to explain how firms formulate and subsequently solve environmental problems.

We examine the case of a multinational supplier in the ball-bearing business which successfully developed a green product line. The entire case is characterized by how the problem formulation for the solution changed over time, although the solution was often the same for different problems. We discuss a four stage interpretation of the case with implications for received theory on problem formulation and problem solving and the implications from a value creation and value appropriation perspective (Björkdahl, 2009).

In the first stage of the problem formulating and solving-process outlined, a customer formulated a problem for ALFA regarding heat generation in a transmission system (problem formulation 1). ALFA evaluated the opportunity to solve the problem but decided against developing a solution after having evaluated the costs and benefits related to the problem.

In the second stage, ALFA was approached by another customer who shared the same basic problem, at least as viewed in hindsight. However, the second customer formulated the problem in a more detailed way, focusing on the problem of lack of stiffness in the arrangement (problem formulation 1.1). Thus the customer had performed the first stage of decomposing the problem. ALFA evaluated the opportunity on the second presentation of the problem and decided to pursue it. ALFA was successful in finding the solution to the second customer's problem and also realized that the solution was applicable to a broader set of problems. Thus, in line with the theory (Simon, 1962), decomposing the problem played a major role in the finding its solution. Figure 1 summarizes the stages.

INSERT Figure 1 ABOUT HERE

In the third stage, having identified a general solution, ALFA formulated a number of specific occurrences or variations of the first problem. It viewed this as finding new applications for the solution. The second stage is illustrated in Figure 2. The lower-case letters refer to variations of the same problem formulation, in the case this corresponds to similar applications for different customers.

INSERT Figure 2 ABOUT HERE

In the fourth stage, interaction occurred between the original problem and a previously formulated green problem. The green problem formulation that eventually impacted on the value proposition of the offers described in the case was formulated by corporate head quarters in an unrelated, process parallel to the problem-solving process in the automotive division. This interaction between problem-formulations enabled ALFA to identify an increased number of business opportunities, i.e. problem-solution pairs. Because the second, green problem was a common problem, this coupling helped ALFA identify a significant number of new business opportunities through the formulation of several new problem-solution pairs. This increased number of opportunities is illustrated in Figure 3 in which problem formulation 2 refers to the green problem formulation.

INSERT Figure 3 ABOUT HERE

Because the interaction between the green problem and the solved problem had such a significant effect, it deserves further elaboration. The origin of the second problem was the very general industry problem of energy costs and the societal problem of CO_2-emmisions, i.e. a "green problem". ALFA had decomposed this problem and identified a particularly valuable sub-problem that they were in the position to find a potential solution to: the problem of friction and power loss in mechanical machinery. From the interaction between these two problems – which occurred when the engineering manager presented his products to the market communications team in 2008 and during the subsequent work on the value proposition – the solution to the first problem was coupled with the second, green problem. The result was identification of several new problem-solution pairs (opportunities). This process of unrelated problem formulation and solving processes is illustrated in Figure 4.

INSERT Figure 4 ABOUT HERE

From the perspective of the problem formulation and problem solving literature the case description reinforces the established observation that problem formulation and solving is a "messy" process (Mintzberg et al., 1976; Lyles, 1981; Nutt, 1984). By comparison, more recent work by Hsieh et al. (2007), describes the process as sequential. That is, with the specific problem first being identified and then the search for a solution. In that regard, our findings contradict the temporal model assumed in Hsieh et al.'s theory about opportunity identification from the perspective of management as problem-solving (i.e. Hsieh et al., 2007). The major implication in this regard however, is that our findings allow for more provision of credence to the well-established iterative view of problem formulation. As outlined in the literature review, most previous research on problem formulation is based on the so-called phase-theorem of problem solving (Witte, 1972; Lipshitz and Bar-Ilan, 1996), which assumes a sequence of events from problem sensing to problem solving. What we identify in our case study is the reverse process of applying an established solution to a new problem. This is illustrated in the case by the fact that the problem formulation process of the green problem and the problem-solving process in the automotive division initially were unrelated and were conducted in different parts of the firm.

Although by necessity models are simplifications of observed relations, we argue that a useful model should capture the dual direction of causation in the modeled problem formulation and problem solving process. Hence, a proper model should take into account that causation may flow two ways, modeled as depending on the current stage in a two phase loop: Problem formulation can lead to a problem solution which, in turn, might be applied to a new problem formulation etc.

From the perspective of value creation and rent generation, the case description shows that initially the problem was formulated as increasing certain performance dimensions in a transmission setup. However, after estimating the cost structure and profit potential of producing the offering, ALFA was reluctant to commit the resources necessary to search for a solution. On the assumption that the appropriation potential was a sub set of the value creation potential, the value created for users from the offering was seen as simply not large enough given the size of the market segment i.e., the number of users for whom the offering would be useful, and their expected level of utility from the solution. Although ALFA eventually did search for and found a solution to the problem, it was not until its discovery that this solution could be applied to other problems – from a specific one of increasing stiffness in a transmission setup to the more generic problem formulation of reducing friction, fuel consumption and CO_2 emissions in user operations – that the articulated value proposition became as developed as currently in terms of the value it creates for users and how much ALFA profits from the innovation.

A key observation related to this process is that the most general customer problem was formulated based on sub problems of an environmental problem; specifically CO_2 emissions and the effects on climate change. Within that problem formulation, the number of users and the number of applications of the technology increased substantially. The solution thus resulted in valuable new opportunities for the firm to take advantage of (Hsieh et al., 2007), and diversification of customer relations and customer applications. From a marketing perspective, the solution developed from a customized pull setup demanded by one customer into a category of solutions pushed onto the market based on a general problem formulation.

As a result scalability and profit potential increased. This paper shows that the formulation into an environmental problem resulted in a situation where the appropriability domain expanded when the problem was reformulated from a specific problem into a wider environmental problem. It is quite possible that the emphasis on the reformulation phase may be characteristic of firms' green problem-solving processes more generally. For example, 1) a new category of formulations of valuable problems has emerged with increased awareness of environmental sustainability, 2) the number of solutions enabled by proprietary knowledge available to firms is unlikely to have increased as rapidly in recent years, and 3) to a significant degree, environmental problems overlap with traditional economic problems, such as the efficient use and allocation of scarce resources. Since identification of an opportunity corresponds to the matching of a valuable problem-solution pair (Hsieh et al., 2007), it should not be surprising if firms' green problem-solving processes tend to focus on the phase that deals with exploring the set of readily accessible and applicable alternatives which, in recent years, has expanded – i.e. the formulations of valuable problems.

This study has some direct implications for management. The case description focused on one example of a situation where green problem formulation expanded the opportunities for the solution owner. One implication for management is that committing resources to the reworking of formulations of valuable problems in relation to existing solutions based on changes in the firms' environment is potentially valuable for the firm. Economizing on the problem formulation phase – the task of searching for the right problem – may result in identification of a limited application area. An important task for the strategic leaders of a corporation is to select a suitable but delimited problem area to apply an existing solution, e.g. recent changes affecting its major customers. Recent regulatory changes based on greater awareness of eco-environmental aspects in many markets are provoking such changes bringing new customer and end-user demands. Thus, managers should not overlook opportunities nor limit resources for possible reformulations of the problems addressed by the solutions owned by their firms to environmental problems.

A reader critical of environmental voluntarism (Newton and Harte, 1997), might see this argument as "greenwashing", since ALFA did not develop a new green solution but simply "renamed" an existing one. However, we would argue that such criticism is unwarranted. The impact on the environment is determined not by intentions but by facts. And by reformulating the problem addressed, ALFA has helped many customers who otherwise may not have bought this solution, to decrease their downstream environmental impact. The response to the argument that intent must exist, ALFA did indeed commit substantial new resources towards the re-formulation of the problem which resulted in the solution. Whether the label of greenwashing applies should not depend on which of two intertwined phases of a problem-solving process resources are directed towards. Since the two phases of problem formulation and problem solving are inextricably intertwined and related (Volkema, 1968; Smith, 1989), committing resources towards one should be seen as equally worthy as committing resources towards the other.

Given that this study is based on one case study further research is needed. However, we can say that the reverse problem solving process described above is a phenomenon that does occur in firms. Further research should focus on how frequently firms identify substantially larger application areas for already developed solutions – i.e. new business opportunities – when considering previously formulated valuable problems in conjunction with environmental problems. If this turns out to be more than a chance occurrence, it could have major implications for literature dealing with how firms could take advantage of the business case for sustainability (e.g. Salzman et al., 2005).

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	View of customer problems	Actions of automotive division	Corporate level actions	External events
2005	First customer approaches Alpha with technical problem	-	Identifies environmental problem of climate change and decomposes into energy waste - decides to position Alpha as provider of energy efficiency solutions	EU Proposal for Council Directive on Passenger Car Related Taxes
2006	Second customer approaches Alpha with technical problem	Develops a solution; Fuel effeciency increasingly discussed		Stern review
2007	Customers increasingly formulate and respond to environmental aspects of problem	Explores alternative applications for original solution; Fuel efficiency & power loss in focus		IPCC 2007
2008	Marketing material now includes the environmental issues addressed by the solution	Solution is mass marketed	Launches 'huge' marketing campaign focused on green issues	Conference on transmissions systems in Berlin

Table 1: Important events in the development of the energy efficient solutions by the automotive division of ALFA.

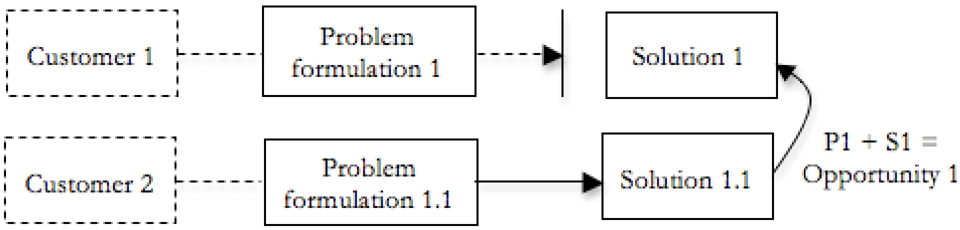

Figure 1: Stages 1 and 2 of the problem solving process

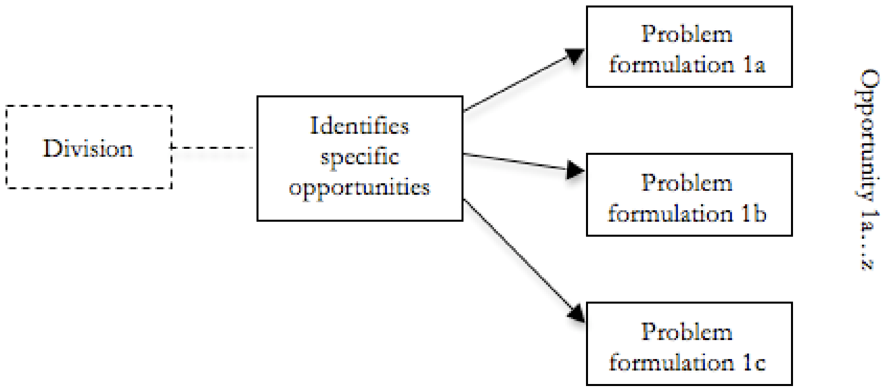

Figure 2: The third stage- Formulating problem variations

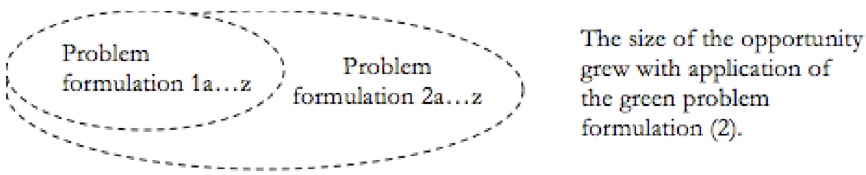

Figure 3: The size of the opportunity increased with the application of the new problem formulation on top of the old.

The figure illustrates that |P1a...z| ∪ |P2a...z| > |P1a..z|

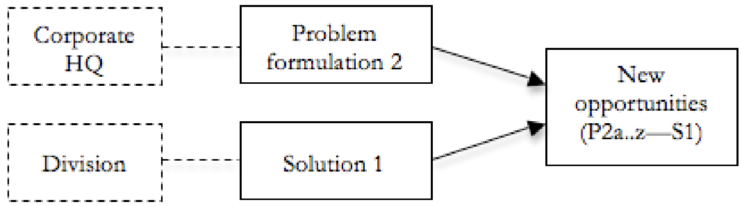

Figure 4: The fourth stage- Problem reformulation. (Note that the process depicted in this figure led to the outcome depicted in figure 3.)