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## Conference Paper

### Early Supplier Integration in Cast Product Development Partnerships – A Multiple Case Study of Environmental and Cost Effects in the German Foundry Value Chain

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# Early Supplier Integration in Cast Product Development Partnerships – A Multiple Case Study of Environmental and Cost Effects in the German Foundry Value Chain

Robert Christian Fandl, Tobias Held and Wolfgang Kersten

## Abstract

Companies have to take sustainability into consideration, nowadays. This paper analyses the impacts of environmental and cost effects on product development partnerships in the German foundry value chain. The starting point of the paper is a survey conducted in the period, end of 2012 / beginning of 2013, covering supplier and customer integration issues on the interfaces of casting houses and their clients, in which all German foundries and customers from diverse sectors of the machine-building industry have been contacted. Based on the results, the authors collected in-depth data, via semi-structured interviews, for several complex product development projects, in order to analyse how suppliers were integrated by their customers during casting development. By analysing cross-case differences, this paper explores how environmental and cost effects impact product development partnerships. It presents a multiple case study analysis, covering four new cast product development cases of one German foundry which deals with four different machine building customers. It is shown that customer-supplier relationships appear to be related to different integration practices. The results demonstrate the substantial impact of environment and cost effects on customer-supplier relationships, and help to understand how sustainable product development partnerships should be configured, while taking the particular situation into account.

**Keywords:** product development partnerships, supplier relationships, environmental and cost effects, foundry value chain

# 1. Introduction

Collaboration between suppliers and customers in new cast product development has environmental advantages and cost effects. Traditionally, the lowest price has been the dominating supplier choosing criteria in the foundry value chain, but the industry is, to some extent, moving towards a more collaborative approach (Institute of Foundry Technology, 2014; Eisto et al., 2010). Fig. 1 shows the framework of cast development partnerships.

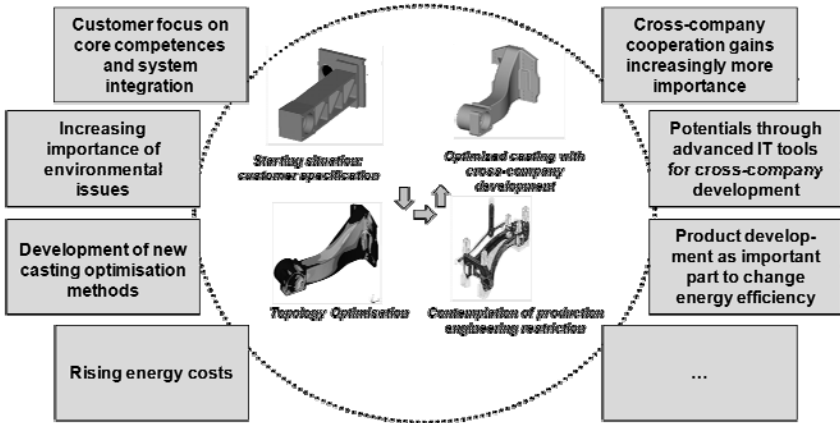


Fig. 1: Framework of cast development partnerships

In Germany, sustainability aspects are gaining increasingly more importance (against the background of increasing worldwide demand for raw materials and energy) and production is increasingly sub-contracted to low cost countries (Kuchenbuch, 2006; Vieweg and Wanninger, 2010; Kupec, 2011; Fandl et al., 2013). German foundries with high labour costs cannot compete on price alone in many cases, but they can compete with product development partnerships covering, for example, different sizes of cast production series, providing ready-to-install casting components (Saarelainen et al., 2007; Thiele and Janjis, 2013). Historically, several methodologies have been developed for evaluating, selecting and integrating suppliers in new product development (e.g. Ellram,

1987; Kamath and Liker, 1994; Peter, 1996; Petersen et al., 2005; Kirst, 2008; John, 2010), which take into account factors such as project times, product quality and project costs. However, the importance of environmental effects in the foundry value chain has been neglected.

## **2. Theoretical framework**

### **2.1 Empirical survey – an overview**

For period, end of 2012 / beginning of 2013, a survey was conducted which covered supplier and customer integration issues at the interfaces of casting houses and their customers. Experts from sales, product development, and management from all German iron and non-ferrous metal foundries were contacted for this comprehensive survey. A total of 1.156 potential participants were reached, from which, 215 participants successfully fulfilled the survey, which represents a response rate of 18.6%. This substantial coverage allowed generalizations to be made, together with a differentiated analysis.

One part of the survey included the current status of certifications; 87% of the foundries are certified by the DIN EN ISO 9001 standard. This standard is the foundation of further certification efforts of many companies in the foundry supply chain. Due to increasing importance of environmental aspects, DIN EN ISO 14001 (an environmental management standard), becomes increasingly more common (Fandl et al., 2013). Currently, this standard is implemented in less than half of all German foundries. The share of certified foundries, according to DIN EN ISO 50001 / EN ISO 16001, which is currently not present at very small companies of <50 employees, is significantly dependent on company size and the respective industrial sectors of their customers (Fig. 2).

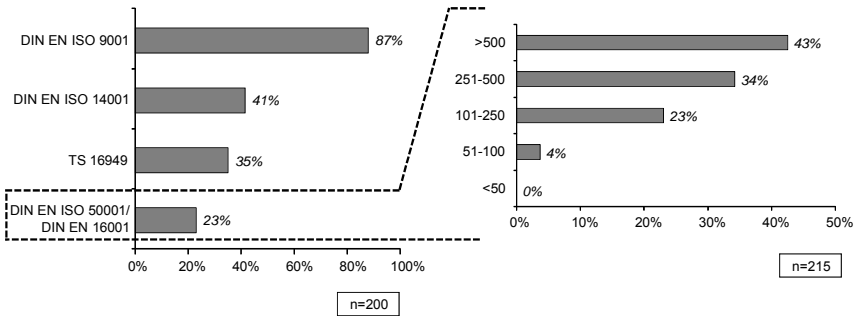


Fig. 2: Certificates of German foundries and split of DIN EN ISO 50001 / DIN EN 16001 certificated companies by size

The empirical survey confirmed that computer-aided design (CAD) software is widely used during cross-company product development projects; however, in many cases, companies use their development tools independently. The sharing of company-specific resources and applied knowledge need to be promoted systematically. Issues are often, the lack of systematic procedures and related challenges arising in the context of product development partnerships. The consideration of interfaces and coordination processes in the product development process plays an increasingly more important aspect in this context. According to the feedback of the respondents, considerable improvement potentials, such as reduction of weight, development time and development costs, as well as improvement of casting functionalities, still exist. The results of the survey reveal that most methods for process improvement, regarding ecological aspects, are currently related to the production area and less to development activities (Fandl et al., 2013). An evaluation of collected free texts identified the following areas with most foundry projects: introductions of energy management systems, heat recovery procedures and investment in more efficient furnaces and exhaust systems. Figure 3 reflects the connection between ecological aspects and collaborative product development. The majority of respondents were convinced that positive effects concerning ecological aspects could be achieved by working in a more integrative manner

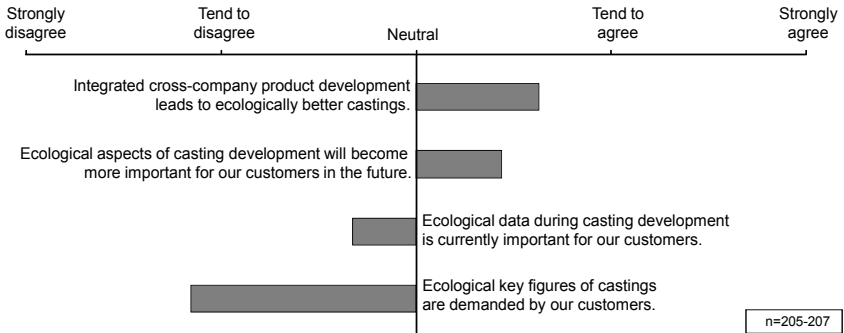


Fig. 3: Cross-company product development and ecological aspects

with their clients during casting development. The survey participants also claimed that, from their customer’s point of view, environmental aspects would be a more important supplier selection criterion in the future (cp. Humphreys et al., 2003). However, ecological aspects are, currently, not considered extensively by foundry customers – most customers expect no statements or key performance indicators concerning environmental aspects from their suppliers.

Only 39% of all foundries had to provide ecological key figures to their customers. If the customers considered ecological aspects during casting development, about 89% of them were interested in energy consumption, 56% in information about CO<sub>2</sub>-emissions and only about 20% in indicators for water consumption (Fig. 4).

Ecological aspects are considered by the majority of respondents, but the importance is rated lower in casting development in relation to the production area. Furthermore, adequate assessment methods were often missing. Regarding ecological aspects, most consideration is spent on energy consumption and CO<sub>2</sub>-emissions. In summary, based on the empirical survey, it could be derived that ecological aspects are playing an increasingly important role (cp. Fandl et al., 2013).

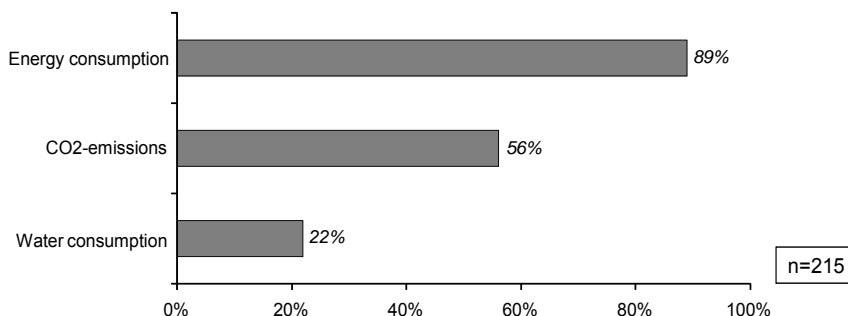


Fig. 4: Ecological data provided by foundries during casting development

## 2.2 Ecological aspects in the foundry value chain

Over the last decades, increasing attention has been drawn to the expected severe effects of global warming (WMO, 2013). The increasing concern puts pressure on companies to reduce their environmental impacts, not only for a particular branch of industry, but for entire supply chains (UNEP, 2012). This is evident from the trend that companies are, increasingly, being held responsible for environmental problems caused by their suppliers (Koplin et al., 2007). According to the World Energy Council, energy costs currently comprise of about 10% of the cost of manufactured products, and that this percentage could escalate to as much as 25% in the next 10-15 years (Robison, 2011).

The industry in Germany is responsible for more than 40% of total energy consumption (Neugebauer et al., 2008). The foundry industry is especially energy intensive. As a consequence, energy savings play an important role for the profitability and sustainability of every German foundry (Trauzeddel, 2009). More than 70% of energy consumption in an iron foundry is in the area of metal melting, molten metal handling and pouring (Institute of Foundry Technology, 2013; Bührig-Polaczek et al., 2014). Although melting is the biggest point of consumption (industry estimates indicate it is approximately 55% of the typical metal caster's costs), many points of energy use present opportunities to reduce costs, significantly (Fig. 5). Following the principle that "only the

measurable is manageable”, the need for a standardised, consistent, and quality-assured tool for measuring and assessing the environmental and cost effects of new cast product development becomes evident.

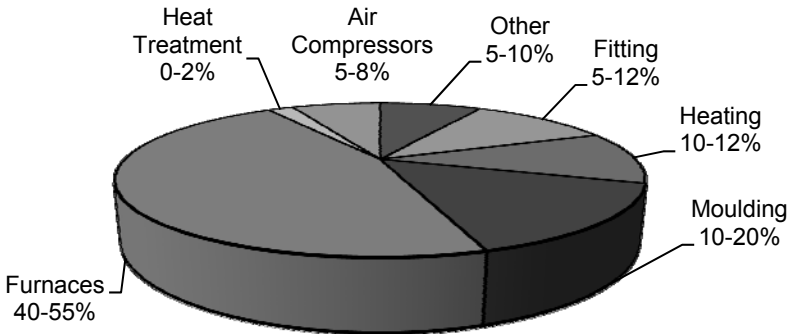


Fig. 5: Energy consumption of German iron foundries (Bosse, 2012)

### 2.3 Development of an IT-tool to assess environmental and cost effects

Previous literature presents several approaches for foundries to deal with environmental issues (Spall, 1997; Huppertz, 2000; Rebhan, 2001; Kuchenbuch, 2006). Based on these starting-points, an in-depth analysis of a German iron foundry was performed. As a result, an information technology (IT) tool, for the calculation of environmental and cost effects, has been created, based on the following data:

- Castings (technical product data for each individual casting)
- Installed operating resources
- Electrical energy consumption for all these individual machines and equipment (e.g. induction furnaces, motors, compressors, pumps, lighting)
- Consumption of commodities (such as natural gas, sand, binder, water)

The IT-tool contains information about the energy consumption of all the machines and technical equipment (282 individual energy-using operating



resources were covered with their load, efficiency and energy consumption) and the costs for each manufacturing process step (e.g. melting, core making and moulding, finishing) were investigated. Input parameters for the calculation are casting details, such as material, weight, number and volume of the cores and pulse time. Figure 6 shows an excerpt of a screen shot of the processes step “finishing” (covering e.g. cast fitting). Undercuts and size of the component are, especially, considered for this calculation.

This tool was used to analyse casting designs that were created by customers without the involvement of casting supplier know-how (“initial customer drawings/specifications”) as well as casting designs that have been created jointly with supplier input (“supplier integrated specifications”).

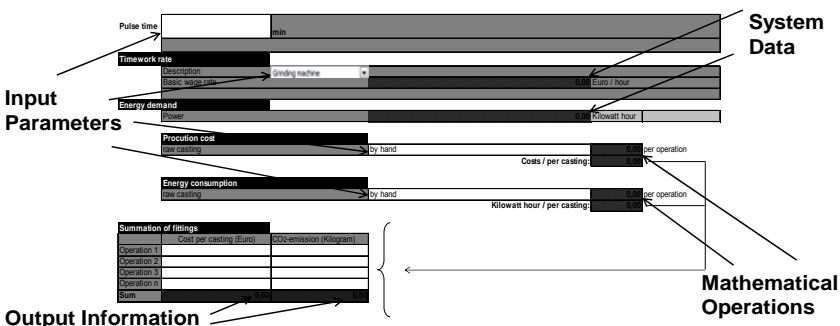


Fig. 6: A screen-shot extract of the IT-tool developed for casting part assessments

### 3. Research design

The research design used in this paper is a case study analysis, which explores and analyses multiple case studies. The research was designed by applying Yin’s (2003) case study principles. The ongoing research included several cases of new cast product development projects, from which four embedded cases were selected for this paper. These four comparative cases were studied

to allow for in-depth understanding (McDonough, 2000) and theoretical replication (Eisenhardt, 1989; Miles and Huberman, 2014).

The case foundry is a medium-sized German iron foundry with a casting development department. The manufacturing process in the case foundry is sand casting and the foundry is certificated by DIN EN ISO 9001 and DIN EN ISO 50001 standards. The four customer companies covered are medium- and large-sized companies of the machine building industry. All the research and development (R&D) departments of the companies are located in Germany. For this paper, the basic data were gathered by document analyses and direct involvement of, and discussions with, experts of the four development projects (Fig. 7).

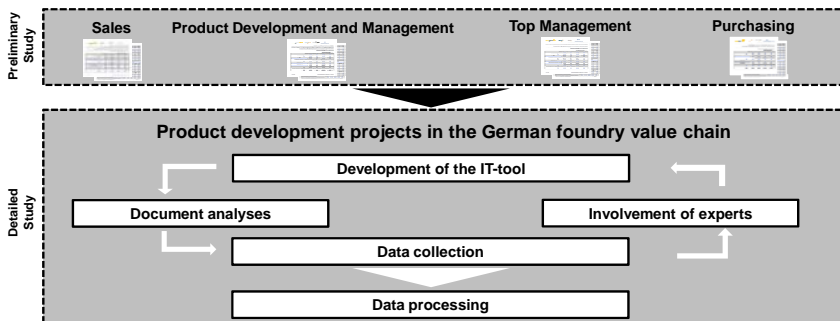


Fig. 7: Research design – an overview

A document analysis is a data collection procedure to collect data, which is already present in written (or digital) form (Prior, 2003). In this research, the collaboration process was defined to begin when a customer contacts the case foundry for the first time, concerning a new cast development project, and to end when the foundry delivers the development report with the final technical drawings and specifications.

The document analyses used the following data:

- Development requests
- Development contracts
- Company profiles of development partners
- "Activity profiles" of the people involved in the development project (e.g. analysis of all project e-mails)
- Technical specifications and drawings (in particular: detailed analysis of all changes in computer-aided design (CAD)-models during project time)
- Interview protocols and status reports
- Final development reports

The documents (CAD-models, specifications, etc.) analysed were complemented with interviews of experts involved from all customers and the casting house. The interviews were semi-structured to be able to capture each case-specific characteristic and to allow for cross-case comparisons. Twelve customer respondents were interviewed face-to-face and the interviews were transcribed (Rubin et al., 1995). These customer interviewees represented purchasing, sales, manufacturing and R&D members. Interviewed people in the case foundry represent top management, sales and R&D.

Following the results of the documents analysed and the interviews conducted with the experts, the data were analysed in two steps (Mayer, 2013). Firstly, the individual case was analysed on a stand-alone basis, in order to highlight the unique patterns of the particular case. Secondly, these patterns were compared with patterns found in the comparative cases, in order to highlight cross-case patterns and differences.

## **4. Four new cast product development cases**

In this section, the four cases are described by discussing, for example, customer company size. For each case, the project studied is first presented (i.e. background, execution and results), and then the section ends with an overview of the projects studied.

### **4.1 Case 1: TORQUE ARM**

This new cast development project was made in the field of “Drive and Control Technology”. The customer is one of the world’s largest companies in this field with over 37.500 employees. The headquarters are in Germany and the company is certified by the DIN EN ISO 9001 and DIN EN ISO 14001 standards. The casting supplier is located over five hundred kilometres away. The customer’s R&D department has more than five hundred employees; but less than ten of the R&D employees have a foundry background. The company uses up-to-date CAD software, finite element method (FEM) calculation tools and extensive project planning software.

The development project started in November 2011 and ended in April 2012. It was the first new cast development project with the case foundry. The customer integrated the case foundry in the development phase and provided a preliminary drawing (3D model), geometric dimensions, and material specifications, as well as further specifications at the first contact. Starting material was “EN-GJS-400” and the casting weight (raw casting) was approx. 1.520 kilograms. The casting is highly complex compared with other casting development projects, due to extensive free-form surfaces. The communication between the customer and the casting house R&D team was, mainly, undertaken via e-mails, on a regular basis. Communication via telephone was only employed occasionally. Limited secured extranet communication was used during the entire project. The customer’s employees visited the case-foundry more than three times.

The project results were, to some extent, unexpected: The material was maintained in a uniform manner, but one additional core was added to the casting process. The customer goals were achieved due to weight reduction, production cost reduction and details of the casting part (e.g. improved stiffness).

## **4.2 Case 2: PINION**

This new cast development project was performed in the field of the “machine and manufacturing systems industry”. The customer has more than 4.000 employees, worldwide, and is certified by DIN EN ISO 9001 and DIN EN ISO 14001 standards. The casting supplier is located approx. eight hundred kilometres away. The customer’s R&D department consists of circa one hundred and fifty employees who use standard CAD software and a FEM calculation tool.

This case started in July 2012 and ended in October 2012. It was the second new cast development project with the case foundry. The casting house was integrated during the concept phase: the customer provided a drawing (3D model), geometric dimensions, load information and specifications. At the beginning of the project, the starting material was “EN-GJS-400” and the casting weight (raw casting) was approx. 1.350 kilogram. This cast part case is more complex, compared with average new cast product development projects of this company, due to the geometric shape and dimensions. The communication during the project was constantly by e-mails. The phone was only used occasionally. The customer did not visit the case foundry, during the entire project period.

The project results were rated as outstanding by the customer, as well as by the casting supplier. The customer has involved the iron case foundry in their concept phase, achieving fast project times, better product quality and lower product costs.

### **4.3 Case 3: MACHINE BED**

Case 3 covers an engineering firm (focusing on printing and paper technology) located in Northern Germany (around one hundred and twenty kilometres from the casting supplier). It is a, relatively, small sized customer with around 120 employees. The company is not certified. The R&D department consists of only two employees using standard CAD software.

The development project of this case started in July 2012 and ended, rapidly, two months later. The customer relationship is one of the longest of the investigated case foundry: This supplier-customer relationship involved more than ten development projects in recent years. The customer integrated the case foundry in the development phase and provided a drawing (3D model), geometric dimensions, material specifications and further specifications (e.g. the required attenuation properties) at the first contact. Starting material was “EN-GJL-350” and the casting weight (raw casting) was 1.982 kilograms. The part is less complex, compared with the “TORQUE ARM” and “PINION” case parts. The communications were, occasionally, via e-mails and, rarely, by phone. The customer did not visit the case foundry during the project period.

The result was an optimised casting with internal core sand. The customer target for weight reduction was reached, but one additional core had to be added.

### **4.4 Case 4: CAST TAPPET**

The last new cast development project covered of this paper, was made in the field of “machine and manufacturing systems industry”. This project was started by a medium-sized customer, with around 200 employees. This company is certified by the DIN EN ISO 9001 standard. The casting supplier is located less than 50 kilometres away. The customer’s R&D department consists of five employees and they used CAD software and a FEM calculation tool.

The case started in October 2011 and ended in December 2011. It was the fourth new cast development project, with the iron case foundry as development partner. Already, during the idea phase, the supplier was

integrated in the development process and a drawing (2D model) and material specifications (“EN-GJS-400”) were sent to the project start. Starting weight (raw casting) was 630 kilograms. This casting is similar in complexity to the “TORQUE ARM” of Case 1. The communications during the project were, constantly, via e-mails and seldom by telephone. During the project time, the customer did not visit the case foundry.

The results of the project were, partly, unexpected: the material was kept the same, but the number of cores could be reduced by four. The customer goals were achieved due to weight reduction, project cost reduction and details of the casting design (e.g. improved stiffness).

|                                 | TORQUE ARM  | PINION                             | MACHINE BED                           | CAST TAPPET                        |
|---------------------------------|---|------------------------------------|---------------------------------------|------------------------------------|
| Environmental management system | Yes   | Yes                                | No                                    | No                                 |
| Geographic distance [km]        | >500  | >800                               | <120                                  | <50                                |
| Development tools               | CAD software, FEM calculation tool, project planning software | CAD software, FEM calculation tool | CAD software                          | CAD software, FEM calculation tool |
| Time line                       | 11.2011-04.2012   | 07.2012-10.2012                    | 07.2012-08.2012                       | 10.2011-12.2011                    |
| Type of customer                | New customer  | Existing customer (one project)    | Existing customer (over ten projects) | Existing customer (three projects) |
| Starting weight [kg]            | 1.520   | 1.350                              | 1.982                                 | 630                                |
| Complexity                      | High part complexity  | Medium part complexity             | Low part complexity                   | High part complexity               |
| Δ Number of Cores               | +1  | -3                                 | +1                                    | -4                                 |
| Quantity [pcs.]                 | ~10   | ~100                               | ~20                                   | ~100                               |
| Integration time                | Development phase   | Concept phase                      | Development phase                     | Idea phase                         |

Tab. 1: Overview of case casting development projects

## 5. Cross-case comparison

In this section, the supplier-customer relationships are compared with each other. In Case 4 (“CAST TAPPET”), the level of integration was deeper than in

the other cases. The foundry was, already, involved in the idea phase and had the possibility of affecting design to a large degree. Previous studies suggest that early supplier integration could bring advantages in a relationship, such as speeding up the new product development process, decreasing costs, and improving the product itself (cp. Handfield et al., 1999; Petersen et al., 2005; van Echtelt et al., 2008). Of all customers, the experts interviewed agreed that early supplier integration could improve castings in many dimensions (cp. Schmidt, 2009) – specifically to reduce weight, development time and development costs as well as help achieve improved functionality of castings. For example, one development engineer interviewed at the customer in the “PINION” case, noted that, collaborative design helped reduce weight in the concept phase to a degree not possible with only in-house tools and know-how. Over a period exceeding ten years, the case foundry has delivered several projects to the customer “MACHINE BED”. In Case 3, the customer (“MACHINE BED”) had requested the case foundry to take responsibility for a lower complexity of the casting in comparison to prior development projects.

The complexity of the manufactured castings seems to correlate with the CO<sub>2</sub>-savings, as well as the amortisation of development cost by production cost savings for the cases analysed (Tab. 2). “Early supplier integration is most effective when implemented designing complex components” as a R&D member of case “CAST TAPPET” stated. Based on the assessment made, a very high reduction in CO<sub>2</sub>-emissions was achieved in Case 2 (e.g. due to low casting expertise of the customer). But, also for Cases 1 and 3, a substantial level of casting part improvement, due to integrated cross-company development, could be achieved.

Another part of this research focused on cross-company development tools which were being implemented. Table 1 illustrates that all the supplier-customer relationships used 3D-CAD software. Additionally, in Cases 1, 2 and 4, FEM calculation tools were used in a cross-company interactive manner. The largest company was the only company that used project planning software for the whole project period, during the “TORQUE ARM” project.



|  | TORQUE ARM | PINION    | MACHINE BED | CAST TAPPET |
|--|------------|-----------|-------------|-------------|
| $\Delta$ -Casting weight [%]                                 | -19.41     | -30.07    | -20.28      | -2.38       |
| $\Delta$ -CO <sub>2</sub> -emissions [%]                     | -9.74      | -16.01    | -10.38      | -6.38       |
| $\Delta$ -Production costs [%]                               | -19.07     | -26.73    | -15.38      | -7.69       |
| Amortisation of development costs by production cost savings | High       | Very high | Medium      | Low         |

Tab. 2: Case comparison of improvement realised

The company size difference between customers and casting houses is seen as a challenge by some interviewees, but not by all. The analysis revealed that there is a strong relationship between the level of certifications and the size of a case company: The DIN EN ISO 9001 standard is already available in mid-size companies; but, environmental standards (such as DIN EN ISO 14001) are, currently, not present at the small- or medium-sized case companies.

Additionally, customers of different sizes had different kinds of company cultures and product development process rigidities, resulting in different levels of supplier integration and communication. In the literature (e.g. Eisto et al., 2010; Monczka et al., 2000; Koufteros et al., 2007; Aune and Gressetvold, 2011), it is suggested that mutual trust, and open and frequent communication, are enabling factors in successful early supplier integration. Factors that create and nurture trust and communication are such as securing reasonable margins for suppliers, and sharing sufficient information at the first contact (Bruce et al., 1995; Chou, 2008). None of the customers allowed the case foundry to see the interfaces of their casting parts in the customer's product or the total schedule of the overall product development project. The type of customer that a foundry has to deal with, and an industry area where a customer operates, also seem to have some influence on the relationship such as, for example, time-to-market requirements and production volume differences.

## **6. Conclusion and outlook**

Limitations of natural resources and increasing awareness of climate changes are forcing a change of paradigms of the sustainable use of raw material and energy. The four cases that were investigated provide some insights in the current situation of early supplier integration in relationships between German iron foundries and casting customers. Based on the results of an analysis of the entire production steps of one German iron foundry, an IT-tool to assess the environmental and cost effects of casting parts was created. This tool makes it possible to calculate the CO<sub>2</sub>-emissions and production costs for each manufacturing process step for castings parts, based on their technical specifications. This tool was used to evaluate the designs of castings parts that have been engineered without involvement of casting houses, with the results that could be achieved by integrated, cross-company casting development.

Product development partnerships between casting houses and their customers seem to take different shapes and depths in German foundry supply chains. By empirically observing four new cast product development cases from the viewpoints of both the supplier and customer, we identified several mechanisms to achieve early supplier integration and improvements of ecological aspects during product development partnerships. Casting design, which has a significant effect on resource efficiency, is therefore opting for reduction in consumption, based on lightweight casting construction and a reduction of complexity. Therefore, the casting production and application of thin walls, geometrically complex castings using high strength, is a result of early supplier integration in new cast product development. In addition, the impact of product upon the environment is determined at the concept phase.

Three-quarters of the case companies are certified by the DIN EN ISO 9001 standard. Due to increasing importance of environmental aspects, the DIN EN ISO 14001 standard becomes increasingly applied. Currently, the standard is implemented in two case companies (and, also, in less than half of all German foundries). The customer interviews confirmed that CAD software and FEM

tools are widely used during cross-company product development projects. Not only by interviewing customers (such as in other research studies, e.g. Handfield et al., 1999), but also by analysing actual technical drawings and specifications, considerable improvement potentials, such as reduction of weight, development time, improvement of CO<sub>2</sub>-emissions and production costs could be detected.

In summary, based on the multiple case study presented, it can be derived that ecological aspects are playing an, increasingly, important role in the foundry supply chain and that the resulting challenges could be mastered to a huge extent, by involving casting house early in the design process, in many cases.

## **Acknowledgements**

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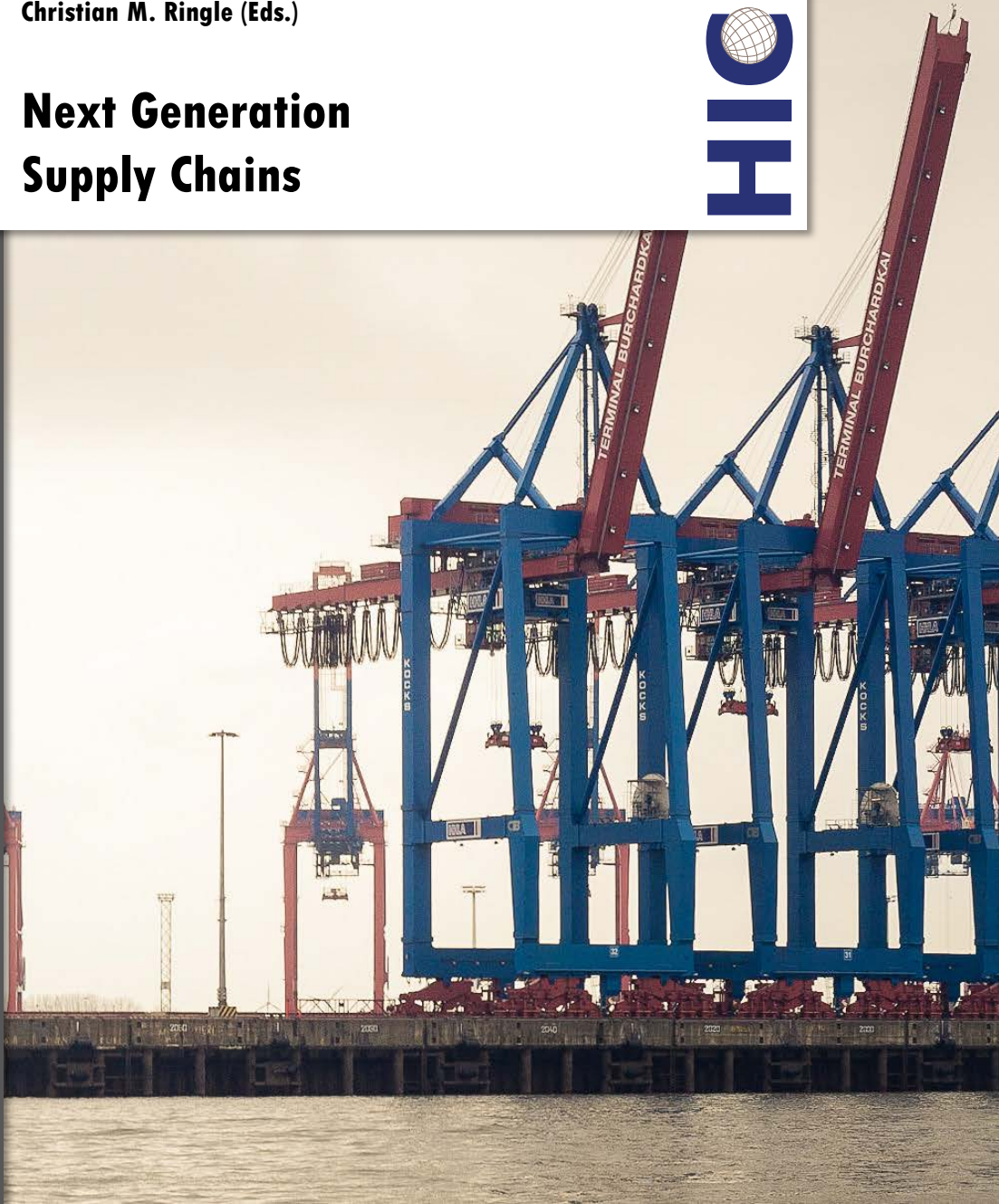
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**Wolfgang Kersten, Thorsten Blecker and  
Christian M. Ringle (Eds.)**

# **Next Generation Supply Chains**



Prof. Dr. Dr. h. c. Wolfgang Kersten  
Prof. Dr. Thorsten Blecker  
Prof. Dr. Christian M. Ringle  
*(Editors)*

# **Next Generation Supply Chains**

Trends and Opportunities



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## Preface

Today's business environment is undergoing significant changes. Demand patterns constantly claim for greener products from more sustainable supply chains. Handling these customer needs, embedded in a sophisticated and complex supply chain environment, are putting the players under a constant pressure: Ecological and social issues arise additionally to challenges like technology management and efficiency enhancement. Concurrently each of these holds incredible opportunities to separate from competitors, yet also increases chain complexity and risks.

This book addresses the hot spots of discussion for future supply chain solutions. It contains manuscripts by international authors providing comprehensive insights into topics like sustainability, supply chain risk management and provides future outlooks to the field of supply chain management. All manuscripts contribute to theory development and verification in their respective area of research.

We would like to thank the authors for their excellent contributions, which advance the logistics research progress. Without their support and hard work, the creation of this volume would not have been possible. We would also like to thank Sara Kheiravar, Tabea Tressin, Matthias Ehni and Niels Hackius for their efforts to prepare, structure and finalize this book.

Hamburg, August 2014

Prof. Dr. Dr. h. c. Wolfgang Kersten  
Prof. Dr. Thorsten Blecker  
Prof. Dr. Christian Ringle

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## **About HICL**

Since 2006 the annual conference Hamburg International Conference of Logistics (HICL) at Hamburg University of Technology (TUHH) is dedicated to facilitate the exchange of ideas and contribute to the improved understanding and practice of Logistics and SCM. HICL creates a creative environment which attracts researchers, practitioners, and industry thinkers from all around the world.



Innovation is increasingly considered as an enabler of business competitive advantage. More and more organizations focus on satisfying their consumer's demand of innovative and qualitative products and services by applying both technology-supported and non technology-supported innovative methods in their supply chain practices. Due to its very characteristic i.e. novelty, innovation is double-edged sword; capturing value from innovative methods in supply chain practices has been one of the important topics among practitioners as well as researchers of the field.

This volume, edited by Thorsten Blecker, Wolfgang Kersten and Christian Ringle, provides valuable insights into:

- Innovative and technology-based solutions
- Supply chain security management
- Cooperation and performance practices in supply chain management

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