

# MANAGING REQUIREMENTS OR BEING MANAGED BY REQUIREMENTS – RESULTS OF AN EMPIRICAL STUDY

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## ABSTRACT

In order to remain competitive, e.g. in the face of globalisation, many small and medium-sized product development manufacturers feel the need to change or refine their development processes. One of the key activities is to systematically translate the needs of customers into development requirements. Little is known about how small and medium enterprises (SMEs) deal with the complex topic requirements management and studies of large numbers of cases are still the exception.

Many SMEs have problems in managing requirements. They often have the capabilities for requirements management but the processes are not well defined, e.g. insufficient monitoring of specifications and poorly organised customer contacts. How to work with frozen specifications and how to handle the wishes of the customers seem not to be fully understood.

This paper presents selected results of an empirical study into product development of SMEs in the UK. The predominantly qualitative data was collected using a questionnaire which was designed as a self-help package.

*Keywords: Voice of the customer, Requirements management, SME, questionnaire, interview*

## 1. INTRODUCTION

In the UK around 130,000 manufacturing companies, of which 15,000 can be classified as Product Development Manufacturers (PDMs), act as a cornerstone of the economy [1]. PDMs are those manufacturing companies that also develop the products they produce and sell. In the UK they provide 60% of the external revenue and half of the services depend on them. In the UK 75% of the PDMs can be classified as small and medium enterprise (SMEs) [2]. According to the definition at the time of the investigation, SMEs have between 10 and 250 employees and a turnover of less than £20 million.

SMEs are faced with some severe challenges. Globalisation and changing business strategies of Original Equipment Manufacturers (OEM), to whom most of the SMEs supply their products, require that SMEs become (more) active in product development. Both the execution and the management of the whole process of product development has to take place at a competitive level [1].

Besides technical knowledge and skills in product strategy development, SMEs need to develop their product development skills, in particular in requirements management, as high quality requirements management is an essential prerequisite for successful product development [3-5].

The aim of the investigation presented in this paper was to obtain a better understanding about the situation in SMEs concerning product development and requirements management, using the data of a study in the UK on product development in SMEs, in which the third author was involved, as the basis. Our assumption is that the situation in the UK does not differ significantly from that of other industrialised countries. Very similar issues and challenges will be faced by all SMEs.

Our investigation was geared towards the following research questions:

- What is the general approach to product development and requirements management of SMEs with above average growth rate as compared to those with below average growth rate?
- What influence do customers have on the product development process?
- What is the situation regarding the management and monitoring of requirements for SMEs?

## **2. THE P<sup>3</sup>I PROJECT**

Between 1997 and 1999 the Project “Partnership for Profitable Product Improvement” (P<sup>3</sup>I), initialised by the UK Royal Academy of Engineering and largely funded by the Department of Trade and Industry, was carried out to improve SMEs performance in product design and innovation [6, 7].

### **2.1. Objectives of P<sup>3</sup>I**

The project was intended to increase awareness amongst SMEs of the need to modify or to develop new products to suit changing markets, to engender a “product development culture” and to reach many more SMEs than would be possible by one-to-one consulting. The project involved the development of a CD self-help package which included a self-assessment questionnaire and information relating to the topics in the questionnaire. The package was to be used by top-management or management teams to reflect upon their situation. To obtain feedback about the process and adjust the package, additional questionnaires were used. To help the SMEs benchmark their own situation, they obtained feedback about their answers to some key-assessment questions in relation to that of all the other participating companies and to those of a similar size in similar domains.

### **2.2. Study Design**

The three part questionnaire comprises 270 questions consisting of around 80 closed questions (quantitative data – part A), more than 180 open-ended questions (qualitative data – part B) and 8 key-assessment multiple-choice questions (part C).

- A The closed questions in Part A provided data about the company, such as company size, nature of the business and growth rate.
- B The open-ended questions in Part B covered issues such as product and market strategy, managing the cost and time of product development, manufacturing and personnel.
- C The key-assessment, multiple-choice questions at the end of the questionnaire were intended to summarise the situation regarding overall capabilities of the companies.

Experienced senior industrialists interested in improving the situation in SMEs were trained as facilitators. They spent at least one day with the company and together with the participants filled out the questionnaire (each participating company spent an average of 18.1 hours on P<sup>3</sup>I). They also helped identify issues the company should address in their improvement process based on the answers in the questionnaire. Through an additional questionnaire for the facilitators, an indication was obtained as to whether the companies correctly assessed their situation and which improvements were suggested.

Of the 650 companies that were contacted, 343 companies participated. More details about the study and earlier analysis can be found in [6-8]. The focus of these publications was on the questions in Parts A and C, on the overall product development process questions in Part B and on the project’s success in achieving its aims.

## **3. METHODS**

### **3.1. Data set**

This paper focuses on those questions related to product development, requirements management and specifications monitoring as well as the influence of the customer on product development. A set of 34 questions were selected, with 9 from part A, 23 from part B and 2 from part C. The most significant results are presented in this paper.

### **3.2. Analysis techniques**

Frequency distributions and dependencies between answers and success of the companies were analysed using standard statistics software. The  $\chi^2$  method was used to identify dependencies. The confidence level was set to  $\alpha=0.05$ .

The answers to the open-ended questions were categorised and coded as nominal or ordinal variables, depending on the type of answers. Inter-encoder reliability tests were carried out on 3 questions. The congruence was between 79% and 86%.

## 4. FINDINGS

This chapter starts with the general characteristics of the investigated companies followed by the results of the analysis of the answers to the selected questions (see section 3.1).

### 4.1. General characteristics of companies involved

The characteristics of the participating companies presented in this section are the result of the analysis of the questions from part A. The sample size  $n$  for each question can vary, because not all companies answered all questions.

- 80.5% of the companies ( $n=335$ ) can be classified as SMEs, 13% of the participating companies have more than 250 employees.
- 42% of the companies ( $n=319$ ) employ 2 designers, 38.4% employ 3 or 4 designers, only 8.9% employ 5 or more designers.
- More than half of the SMEs (57.4%,  $n=122$ ) are involved in international markets.
- Most of the companies (81.5%,  $n=319$ ) answered that they have more than 25 customers.
- Asked for their relative growth rate, 16% answered that they are below the sector average, the groups which answered they are equal to sector average or above the sector average are both the same size, with 42% each ( $n=338$ ).

The sample is made up of companies from several branches (see Figure 1). The largest share is from companies developing mechanical components (13%), mechanical equipment machines (15%) or mechanical engineering (13%).

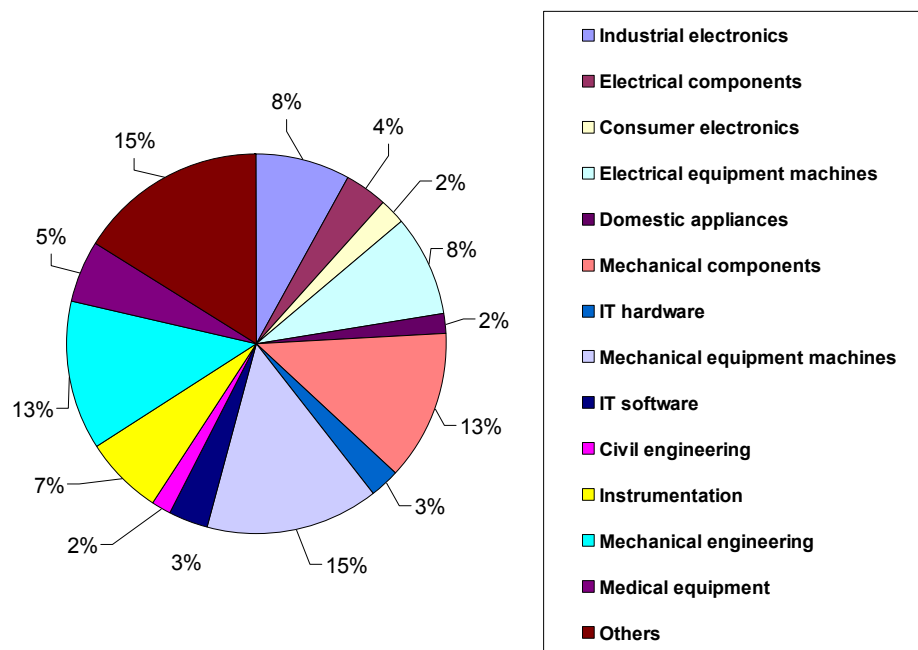


Figure 1. Distribution of branches ( $n=343$ ; part A)

### 4.2. Capabilities related to the product development process and requirement management

In Table 1 the distribution of the answers to the question “On which activities is your company knowledgeable, for which services do you buy in external assistance, and which do you not do at all?” is shown. A list of activities was provided. The results for the activities “requirements specification”, “design”, “development testing”, “market analysis and forecasting” were selected.

Two thirds of companies do their own requirements specification and design without involvement of others. About half of the companies do development testing without the involvement of others. Slightly more than half of the companies declared they do market analysis and forecasting, but with external assistance (partial capability). Only a minority stated they do not do these activities or only

buy in external assistance. Unfortunately the data does not allow a distinction between companies not doing the activity and those having it done by others.

*Table 1. Product development capabilities (part A)*

Answer options	Frequencies (percentages)			
	Requirements specification capability (n=337)	Design capability (n=337)	Development testing capability (n=337)	Market analysis and forecasting capability (n=336)
A Do not do/buy in external assistance	30 (8.9%)	18 (5.3%)	46 (13.6%)	63 (18.7%)
B Partial capability	85 (25.2%)	76 (22.6%)	124 (36.8%)	186 (55.4%)
C Full capability	222 (65.9%)	243 (72.1%)	167 (49.6%)	87 (25.9%)

Asked “Are these requirements [those that they specify] essential to what the customer wants of the product’s performance or could they be relaxed?” 61.2% (n=139; part B) of the companies stated that the requirements they are specifying are essential to what the customer wants.

In Table 2 the frequencies of the answers to the key-assessment question “What is your manufacturing strategy and how does it relate to what your customers want?” are shown (only one option possible). Nearly half of the companies stated that their strategy is to develop processes to reduce cost, improve quality and give the company a manufacturing edge. Note: the answer options are listed more or less according to maturity, ranging from A = low to E = high.

*Table 2. Manufacturing strategy (n=333; part C)*

Answer options	Frequency (percentage)
A We try to make what our customers want, if and when we can.	28 (8.4%)
B We are constantly trying to keep our production facility utilized.	57 (17.1%)
C We have a strategy to keep our production flowing without interruption.	47 (14.1%)
D We develop processes that reduce cost, improve quality, and give us a manufacturing edge.	148 (44.5%)
E We research and anticipate market trends (...) and we build and install technically advantageous tools and equipment to provide a strategic product of high quality.	53 (15.9%)

To obtain insight into the influence of the customer on the initialisation of new product development programmes, the subjects were asked “What part do the requirements and needs of your current and future customers play - as interpreted by market analysis - or do product development programmes just happen because of a good idea?”. The majority answered that their development programmes are mainly market and customer driven (see Table 3).

*Table 3. Initialisation of development programs (n=149; part B)*

Answer categories	Frequency (percentage)
Product development programmes are mainly idea driven.	5 (3.4%)
Product development programmes are mainly market and customer driven.	106 (71.1%)
Product development programmes are driven by ideas, market and customer.	38 (25.5%)

Asked “Do you compare the final product with the specification throughout every stage to ensure that the specification does not creep?” half of the companies answered that they monitor the observance of specifications regularly. Only a quarter answered that they do not monitor the specification. However, this question was only answered by 92 subjects (see Table 4).

*Table 4. Monitoring specifications (n=92; part B)*

Answer categories	Frequency (percentage)
We don't monitor specifications.	24 (26.1%)
We monitor specifications to a degree.	21 (22.8%)
We monitor the observance of specifications regularly.	47 (51.1%)

Asked “Have you clearly defined your goals in relation to the ‘products’ you are providing and the markets and customers you are able to access?” the majority stated that they have defined goals or believe so (see Table 5).

*Table 5: Definiton of goals (n= 160; part B)*

Answer categories	Frequency (percentage)
No, our goals are not clear defined at the present.	22 (13.7%)
Our goals are only partially defined / redefined or under development at the moment.	39 (24.4%)
Yes, we have defined goals or believe so.	99 (61.9%)

In Table 6, the distribution of the answers to the question “Are you using a frozen specification so that you don't have continual interruptions and delays to accommodate changes?” is shown. The number of companies that freeze their specification is equal to the number that does not do so.

*Table 6. Using frozen specifications (n=286; part B)*

Answer categories	Frequency (percentage)
We don't use frozen specifications.	120 (41.9%)
Sometimes we use frozen specifications.	52 (18.2%)
We usually use frozen specifications.	114 (39.9%)

In Figure 2 the relation between the requirement specification capability (see Table 1) and the self-assessed relative growth rate is displayed<sup>1</sup>. This result fails the confidence level marginally with  $p=0.053$ . However, it can be observed that companies which stated that they do not do requirements

<sup>1</sup> The multiple-choice growth rate question offered 4 answers: “below sector average” (15.9%), “equal to sector average” (41.9%), “comfortably above sector average” (24.5%) and “one of the leaders” (17.7%).

specification or buy in external assistance are more likely to belong to the group with below or equal average growth rate than these with full capability.

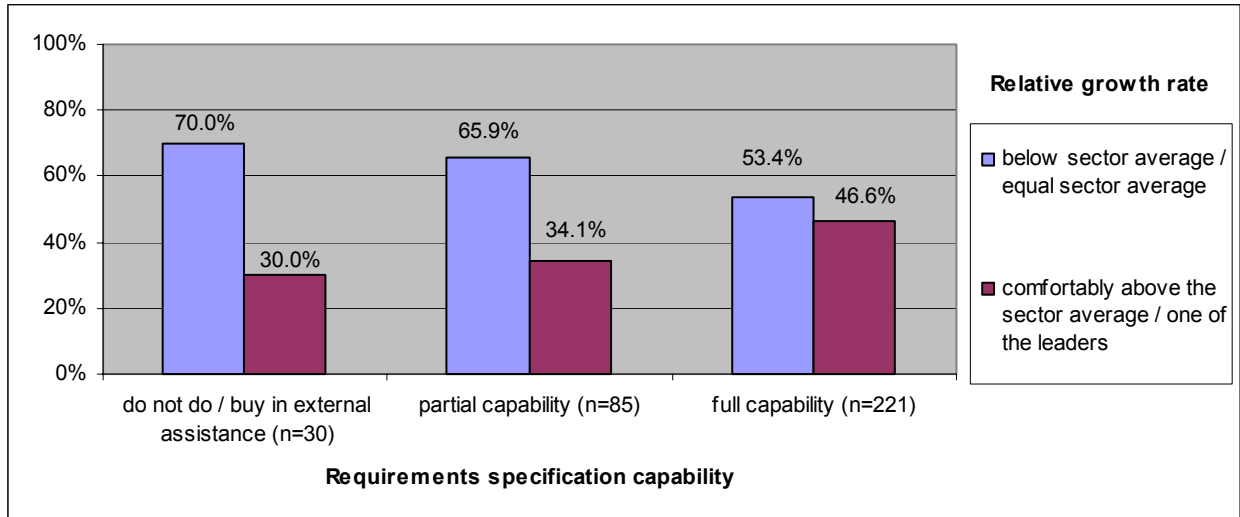


Figure 2. Relative growth rate / Requirements specification capability ( $\chi^2$  prob.0.053; n=336)

### 4.3. Customer relations

In the following, an overview of the results related to the questions that focus on customer relations is given. The following three questions were selected from the questionnaire:

- “Do you think you provide your customers with solutions to their business needs?” (Figure 3)
- “Do you have a scheme to liaise continuously with your customers in order to provide education and training for your company staff in researching your customers’ requirements?” (Figure 4)
- “Are you continually bogged down by customers insisting on bespoke modifications that impose cost and delivery problems?” (Figure 5)

As displayed in Figure 3, most (83.7%) of the companies stated they are in touch with their customers’ needs. Only 6.5% declared that they were at the moment not in touch with their customers’ needs.

Figure 4 illustrates that half of the subjects (51.4%) felt that their company did not liaise continuously with their customers.

Finally Figure 4 shows that the majority of the companies (61.6%) were continually bogged down by customers insisting on bespoke modifications (see Figure 5).

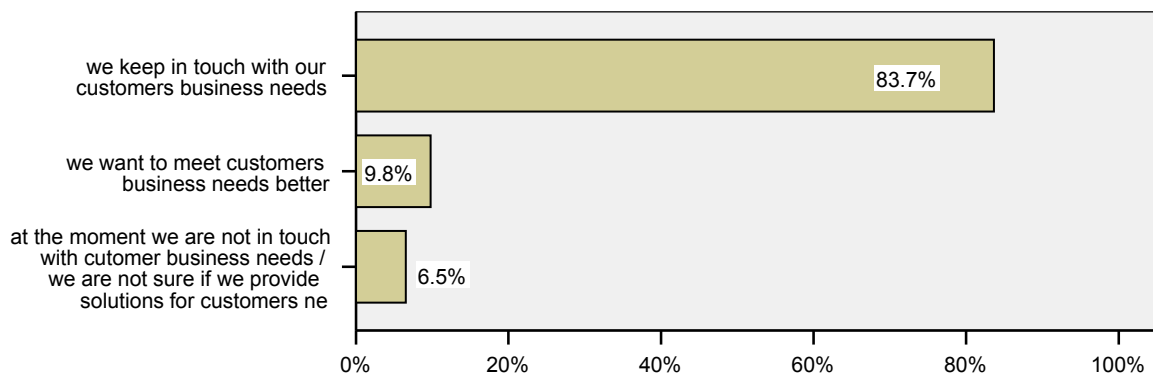


Figure 3. In touch with customer needs (n=306; part B)

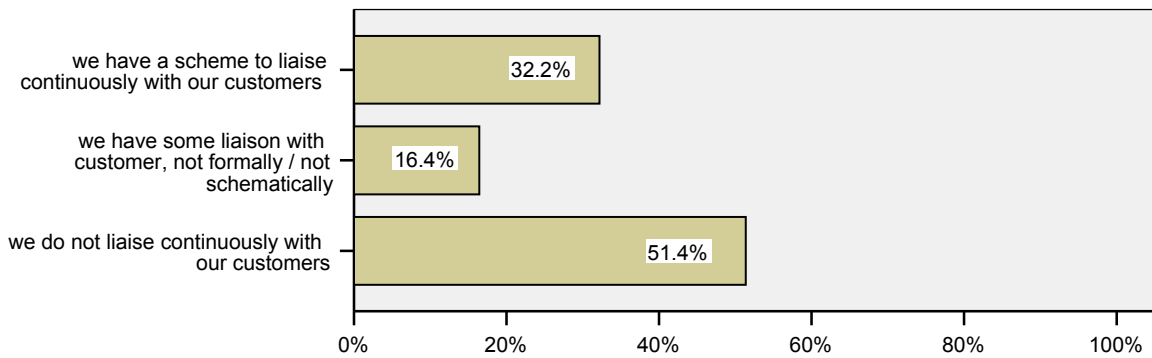


Figure 4. Liaising with customers (n=146; part B)

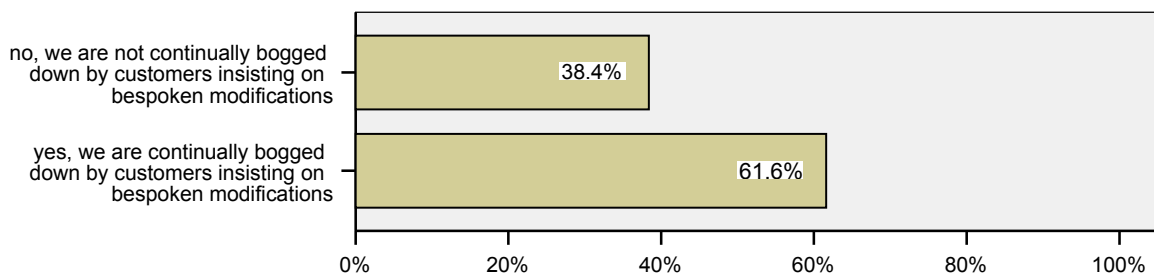


Figure 5. Influence of the customers on product development (n=323; part B)

#### 4.4. Influence of the customer on the product development process

The importance of contact with the customer for the success of the company is documented in Figure 6. Of the companies which state they are not in contact with their customers' business needs (Part B) 84,2 % belong to the group with equal or below sector average growth rate (p=0.042).

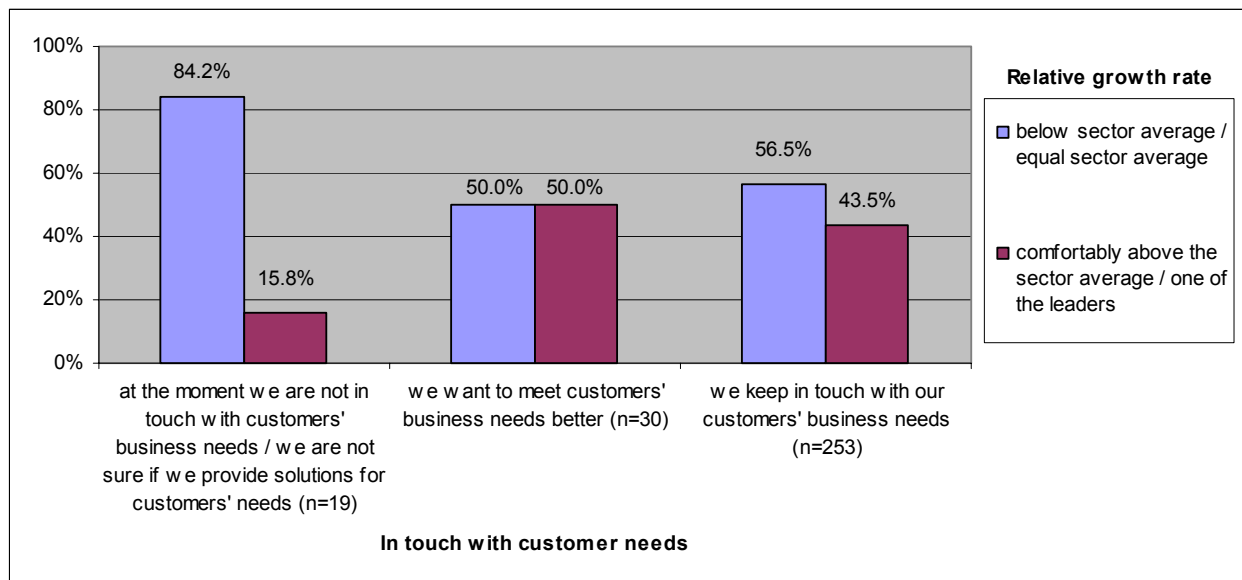


Figure 6. Relative growth rate / In touch with the customer needs ( $\chi^2$  prob. 0.042; n=302)

Figure 7 shows that most companies (85%) which stated that their goals were not defined (Part B), belong significantly more often (p=0.019) to the group of companies which were continually bogged down by customers insisting on bespoke modifications than companies with defined goals (Part B).

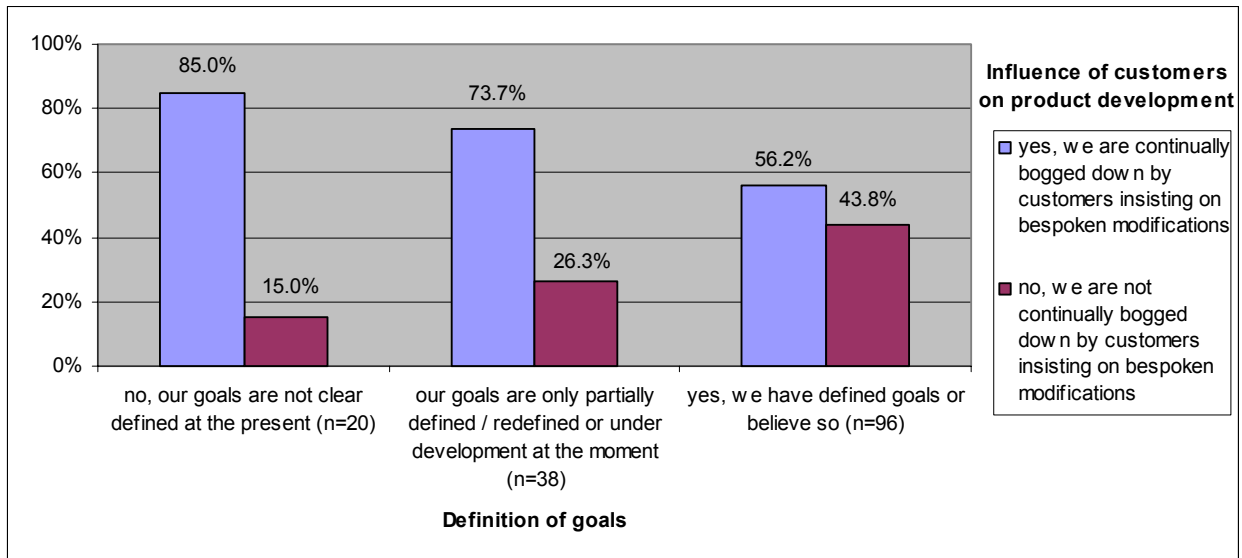


Figure 7. Influence of the customers on product development / Definition of goals ( $\chi^2$  prob. 0.019; n=154)

As already pointed out, the relationship between customers and companies is found to be important for the success of the companies in the sense of growth rate. Figure 8 shows the relation between the manufacturing strategy of the companies (Part C, see also Table 2) and the influence of customers on product development (Part B). Interestingly, most companies (85.7%) which state that their manufacturing strategy is focused on customer needs, belong to the group of companies which are bogged down by customers insisting on bespoke modifications ( $p=0.042$ ).

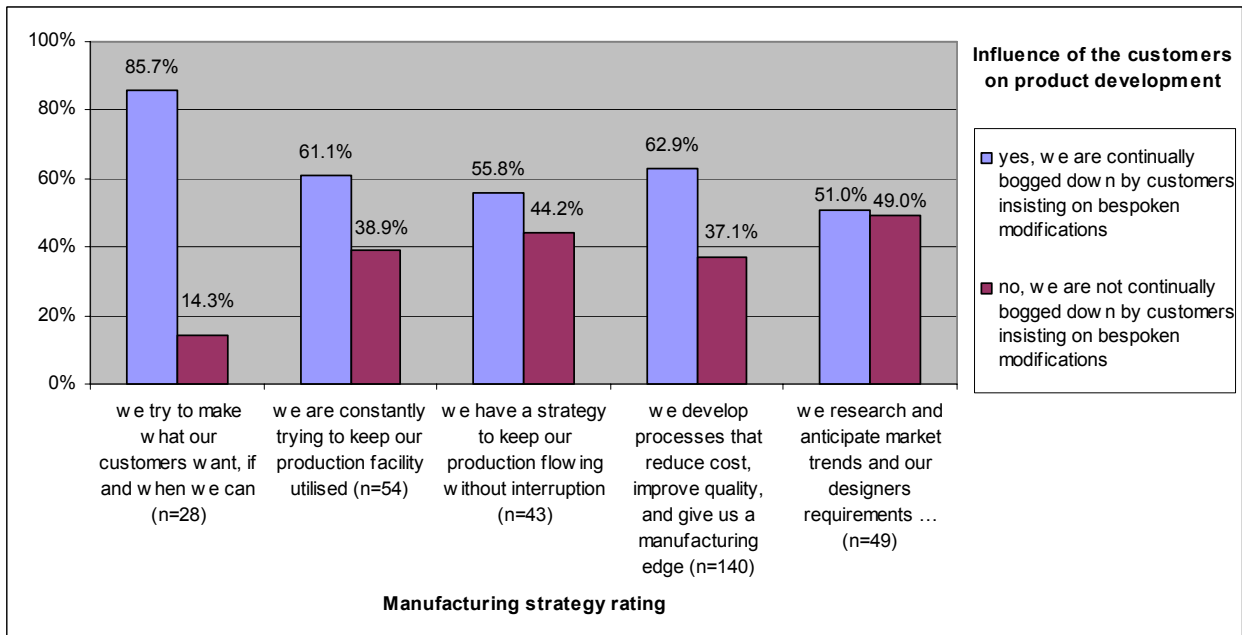


Figure 8. Influence of the customers on product development / Manufacturing strategy rating ( $\chi^2$  prob. 0.042; n=314)



## **5. DISCUSSION**

In this section the results are discussed with the aim of answering the research questions formulated in section 1.

### **5.1. What is the general approach to product development and requirements management of SMEs with above average growth rate as compared to those with below average growth rate?**

The general approach of the SMEs involved in the study can be characterised by full capabilities in requirements management and design and full or partial capabilities in development testing and market analysis and forecasting (see Table 1). More than two-thirds (71%) of the companies state their development programmes are mainly market and customer driven (see Table 3) and further 25.5% state their development programmes are driven by ideas, market and customers. Looking at the manufacturing strategy, only a few companies (8.4%) are customer oriented (see Table 2).

Successful companies (successful in this context means above average growth rate and no problems with customers insisting on bespoke modifications) as compared to less successful companies:

- Have full capabilities in requirements management,
- Are in touch with their customers,
- Have clear defined goals, but
- Do not focus only on their customer wants.

### **5.2. What influence do customers have on the product development process?**

Most of the companies stated that the requirements they specified are essential for realising what the customer wants from the product's performance. Approximately 80% kept in touch with customers business needs (see Figure 3) although 51% stated they did not liaise continually with their customers (see Figure 4).

The companies recognise the importance of taking care of the customers and their needs but nevertheless more than half of the investigated SMEs regularly run into problems during product development because customers tend to change their wishes and demands for product features (see Figure 5).

As expected, a clear trend can be observed between the stage of maturity of the goal definition process and the influence of customers who insist on bespoke modifications (see Figure 7). The more clearly the goals are defined, the less the companies are bogged down by customers insisting on bespoke modifications.

### **5.3. What is the situation regarding the management and monitoring of requirements for SMEs?**

Requirements change management on the basis of frozen specifications are crucial issues within a defined requirements management process and a potential success factor for every product development process [9]. However, most of the companies do not freeze their specification list (see Table 6). Standardised monitoring of specifications also seems to be a problem, because less than half do this regularly (see Table 4).

Companies with full capabilities in requirements management are more likely to belong to the group of companies with an above average growth rate (see Figure 2). The converse can be observed for companies which state they are not in touch with their customers' needs (see Figure 6).

Nevertheless, this does not mean companies should continuously follow each customer's change of mind. Those companies that said that they tried to make what their customers wanted, had significantly more problems with customers insisting on bespoke modifications (see Figure 8). This indicates an inadequate requirements change management approach including capture of requirements, monitoring and adjusting them with their customers.

## **6. CONCLUSION**

This paper shows that a holistic approach to requirements management processes is essential for successful product development. As investigated, the understanding of many SMEs often does not show that holistic approach.

The SMEs deal very differently with requirements management. Many SMEs have the requirements management capability but the processes are often not well defined, e.g. insufficient monitoring of specifications and poorly organised customer contacts. There seemed to be inadequate understanding of how to work with frozen specifications and how to handle the wishes of the customers: almost two-thirds of the companies are bogged down by customers insisting on bespoke modifications. This signifies a potential for improvement.

The needs of the customers should be channelled within a clear process for requirements change management to support the company success. For a more detailed insight, further investigation of the definition of the related processes and their management is needed.

The self-help package as a result of the P<sup>3</sup>I project was a cost-effective way of suggesting areas for improvement in a company's performance. The very extensive dataset supports the identification of fundamental problems of SMEs, but further research has to be undertaken for the analysis of the reasons behind the problems.

## ACKNOWLEDGMENTS

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