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INVESTIGATION OF THE EFFECT OF CUSTOMER-SUPPLIER RELATIONSHIPS IN THE DIE AND MOLD INDUSTRY ON THE INTRODUCTION OF NEW PRODUCTS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of the Ohio State University

By

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ABSTRACT

The pressures to reduce lead times, lower costs, and satisfy customers have led manufacturing companies to place extensive demands on their suppliers. It is now typical for firms to place responsibility for the design and development of product components and subsystems on suppliers.

The participation of suppliers in new product introductions is common when the supplied item is a product component. However, new approaches to product development also call for the participation of tooling manufacturers and suppliers of production equipment.

This research utilizes case studies to investigate changing demands on the die and mold industry. 23 respondents were interviewed at 10 die and mold manufacturers. The companies represent a broad cross section of the industry, including manufacturers of die casting dies, injection molds, SMC molds, glass molds, and sheet metal stamping dies. Both captive and independent firms participated. Respondents ranged from die makers and tool room supervisors to company presidents.

The participation of die and mold manufacturers in product development, and the impact they have had, is described. Because the demand for tooling
manufacturers to play a role in new product introductions is not uniform throughout the industry, the reasons for their participation have been determined.

This study yielded four important results. First, die and mold manufacturers are likely to be asked for input into product design decisions early in a new product introduction only when the component they supply tooling for has strategic value with respect to the marketability of the product. Second, the input of die and mold manufacturers is needed in design decisions, primarily because there is not a stable, experienced workforce in customer organizations. Third, supplier participation in product development is often viewed negatively by persons in the customer's company who feel threatened by dependence on outsiders. Finally, captive tooling suppliers are not more likely to be involved in the product development activities of their customers than are independent tooling suppliers.
Dedicated to the memory of
Aunt Ellie and Aunt Ouida.
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CHAPTER 1

INTRODUCTION

Manufacturers are constantly faced with the pressures of conceiving new products and then introducing them before their competitors' new products reach the marketplace. The ability to compress the development cycle of products that will meet or exceed market expectations is a key competitive weapon for today's manufacturers. Consequently, management tools and technological advances that enable the rapid development of quality products are being sought, proposed, and experimented with widely.

Companies must examine and optimize their product development activities, including the roles played by their suppliers, subcontractors and customers, in order to remain competitive. Several links in the manufacturing supply chain have been the focus of intense scrutiny regarding their role in the overall process of introducing a new product. It must be the goal of each organization involved to have a high quality product reach the market at the earliest possible date and lowest possible cost. However, attaining such a goal locally is insufficient. It is not only the performance of each individual
organization or functional group, but also the interactions between these organizations and groups, that will determine the success of a product development project.

This research focuses on one segment of the manufacturing supply chain, the design and fabrication of dies and molds, and its changing role in the introduction of new products. The objective is to discover the underlying characteristics of the relationships between die and mold manufacturers and their customers, and the role of die and mold manufacturers during product development, and to determine how these factors impact the industry and affect the lead times and costs for dies and molds.

A large variety of products contain components that are made using a net shape manufacturing process. These processes, such as die casting and injection molding, forging and sheet metal stamping, produce discrete parts to net shape or near net shape; that is, parts requiring relatively little subsequent finish machining or preparation before being assembly-ready. A common characteristic of these processes is the use of a die or mold to shape a blank or molten material. Therefore, the design and manufacture of dies and molds are key activities in the introduction of many new products, and performance of these activities will affect the cost, quality, and production schedules of manufactured goods.

Manufacturers of consumer and industrial products face intense pressures from the marketplace to continually improve products and to supply a diverse
product line. This pressure is present throughout the manufacturing supply chain. The demand for high quality, lower costs, and faster delivery is especially acute in the manufacture of dies and molds. As product life cycles become shorter, product development projects are initiated more frequently, and the number of dies and molds that need to be produced increases. Additionally, there is a chronic shortage of skilled die and mold makers. Consequently, the pressures in the die and mold manufacturing industry are only expected to intensify.

One strategy for shortening the lead time for dies and molds is to involve die and mold manufacturers earlier in the product development process. Some product development strategies being embraced by manufacturing firms advocate an attempt to include considerations for the design and fabrication of dies and molds early on in their product development cycles, but for most it is still an “over the wall” activity. Still, the impact of including suppliers of dies and molds in the new product development process during the early stages is largely unknown.

If decision makers in assemblers' organizations are to have the information necessary to determine how, when, and in what capacity to include the suppliers of dies and molds, they will need to know how to structure their activities, what characteristics to look for and develop in these suppliers, and what the potential benefits and hidden costs will be. Similarly, if the trends of increasing the number of activities that are subcontracted and
involving supplier companies in product development decisions continue, die and mold manufacturers that plan to remain competitive must prepare to offer and market the capabilities that will be required of them in these new roles.

The questions that have been addressed by this research are:

- Why do die and mold manufacturers get involved in the product development activities of their customers?
- What roles do die and mold manufacturers play in the product development activities of their customers?
- How do changes in product development practices affect the die and mold industry?
- How has early involvement in product development affected the product cost and delivery time of the die or mold?

In answering these questions, the primary objectives to be fulfilled are:

1. to model the interaction of die and mold manufacturers with their customers; including the services provided and participation in product development activities;

2. to identify current product development practices that serve as obstacles in the design and fabrication of dies and molds, preventing the expeditious introduction of new products;

3. to identify current product development practices that enable rapid design and fabrication of dies and molds;

4. to propose changes in the strategies of the organizations involved that will aid in optimizing the product development process.
CHAPTER 2

BACKGROUND AND LITERATURE REVIEW

This research was motivated by several factors, including personal observations in die and mold manufacturing facilities and the sentiments communicated by die and mold manufacturers. Investigation into the history of the industry, and the review of trade publications and relevant literature in various fields confirmed the need for addressing the research and provided focus for the research questions and the methodology chosen to address them. This chapter contains an introduction to the organizational environment that is the focus of this study and a review of the extant literature that is relevant to the research problem. Note that the material presented in this chapter reflects information available in the literature before any data were formally gathered as part of this study. Current characteristics of specific segments of the industry that were included in the study are summarized in the presentation of the data in Chapter 5.
2.1 An Overview of the Die and Mold Manufacturing Industry

The making of dies and molds is a capital intensive, $23 billion a year industry [1]. Most of the businesses are small, having fewer than thirty employees. The majority of the shops are independent, and compete for jobs among a variety of customers in the automotive, home appliance, electronics, sporting goods, and other industries. However, there are companies that operate their own, captive die shops that service their internal production needs exclusively. These captive tool rooms tend to be larger and have more modern, high-tech equipment than the independent organizations [2, 3].

Depending on the manufacturing process to be used and the size and complexity of the part to be manufactured, a set of dies or molds can have a lead time of up to two years [4]. Regardless of the overall product complexity, this can be a significant portion of the product development cycle. Typically, the fabrication of dies and molds does not begin until after final part designs have been approved. The ramp-up to full-scale production cannot begin until the die or mold has been proved to produce acceptable parts.

The cost of a die set for a single part can easily exceed $500,000, and these costs may constitute ten to twenty percent of the life cycle costs of a product. The cost of the tooling fabrication is a fixed expense, and independent of the production volume. Of course, long production runs may

---

1 Examples of captive die shops in the literature were in the automotive industry.
incur additional tooling costs in the repair or replacement of worn dies or molds. Although dies and molds are often considered production equipment, their cost, like the costs of product development activities, must be recovered from sales of a single product or product family. This is in contrast to other production equipment and inputs, such as machine tools or factory floor space, which can be amortized over the course of several product life cycles. Consequently, tooling is often one of the highest cost items associated with the introduction of a product that requires newly designed components.

Although it is a goal of both die and mold manufacturers and their customers to reduce both the costs and lead times associated with custom tooling, the reduction of lead times is often stated as the primary objective. In the race to the market, buyers are often willing to pay a premium for a short turn-around time.

Because the output is a one-of-a-kind, make-to-order product, mass production techniques are generally not applicable in die and mold manufacturing. Traditional and modern machining processes are used in a job shop environment. The specific operations required vary depending on the type and size of the die or mold, but typically include casting, milling, electro discharge machining, and grinding, as well as heat treating, the application of coatings and surface treatments, automatic and manual polishing, and

---

2 It is possible for dies to be made in small lot sizes, up to a dozen, especially for die casting dies. However, the majority of programs are for a single die set.
assembly. Die tryout is also often performed before the finished die or mold is shipped.

Traditionally, a die set or mold was fabricated in a job-shop and assembled by one or two highly skilled diemakers, who would see the project through from beginning to end. The entire process was extremely labor intensive; an entire die set for a complex part might take as much as 20,000 man-hours to design and fabricate [3]. To obtain a quality product, the diemakers had to have a good understanding of the component to be manufactured and the manufacturing process and equipment that would be used. Today, more modern facilities utilize computer numerically controlled (CNC) machine tools which are less dependent on the operator skill, and some operators serve primarily as process monitors. Assembly and finishing of dies are still accomplished manually by a die maker. Die finishers are among the most highly skilled persons in the industry.

Two decades ago, companies that produce dies and molds saw their primary challenges as being a shortage of skilled workers and competition from captive mold shops [2]. These factors are still relevant in the die and mold industry [1]. However, also of great concern are the challenges of maintaining quality while cutting lead times and costs, in order to compete in a global

---

1. This is dependent primarily upon the manufacturing process and not on the size or complexity of the part or the cost of the tooling.

2. Die makers made the process and die design decisions, performed much of the fabrication of the die components, and all of the die construction.
marketplace, and effectively managing customers, in order to establish long-term, mutually beneficial relationships [5]. Foreign competition is a growing concern, even while there are new opportunities for servicing international customers [6, 7].

The sophistication of facility operations in most organizations in the die and mold industry lags that in many other manufacturing industries. Market pressures brought on by global competition have pushed the boundaries of organizational innovations during every phase of a product's life cycle. The results have been such practices as concurrent engineering, supply chain partnerships, formal methods for manufacturing resources planning (MRPII) and statistical process control (SPC), sophisticated shop floor control and management techniques, and the advancement of manufacturing process technologies. These techniques are just beginning to impact the manner in which die and mold production is planned and executed. In many die and mold manufacturing organizations, there are no formal operations policies, and activities such as estimating, order acceptance, scheduling, and expediting of orders are performed on an ad hoc basis [8-10].

Much of the research that directly addresses improving die and mold manufacturing is concerned with the technological aspects of the field. For example, there has been extensive research on materials for dies and molds, automation of die and mold design, automated polishing of die and mold surfaces, high speed machining, geometric modeling and the exchange and
translation of electronic data. Application of advanced moldmaking techniques has resulted in cutting the lead times by up to fifty percent and reducing the time spent on manual operations by as much as forty percent [3. 11]. Trade publications discuss the current practices in die and mold organizations and experiences with the most advanced equipment [1. 11-13].

Advances in the making of dies and molds have stemmed from the availability of advanced materials, greater precision in machining die and mold surfaces due to CNC, computer aided design (CAD) and computer aided manufacturing (CAM), sophisticated measurement systems, and the ability to handle product data electronically. The sources of these advances are most often equipment vendors, raw materials suppliers, and academic research. Research is also performed by large companies that have captive die shops. Independent die and mold manufacturers rarely have the resources, both in terms of personnel and idle machinery, to investigate the viability of innovative approaches [14].

Unfortunately, some of the problems expressed by die and mold manufacturers are not addressed by technological change. These include problems with flow of information to and from their customers and limited flexibility in product acceptance procedures. These are coupled with a reluctance on the part of customers to allow die and mold manufacturers to implement innovative approaches that might result in cost and lead time improvements. Because of the high costs and long lead times characteristic in
the industry, new ideas are not enthusiastically embraced; the cost of a failed experiment is too high. It is more desirable to utilize methods that are tried and true, even if they are suboptimal.

Another area which has received little attention is the management, operations, and strategies of die and mold manufacturing organizations or companies that share their business environment. Strategies for aiding decision making and improving operations in die and mold manufacturing and make-to-order companies have been addressed in a limited number of studies and trade publications (see, for example [8, 9, 15-19]).

In the 1960s, studies were conducted that focused on the tool and die industry in Michigan. These included a survey of the practices in the industry [20], an investigation into the overall effectiveness of captive die shops and their effect on the industry [14], and a characterization of the changes taking place in the industry [21]. A later study, in the mid-1970s, characterized the industry, suggested practical approaches to cost analysis and pricing, and revisited the economic problems of independent versus captive tool and die shops [2]. Although the most recent of these studies was completed over twenty years ago, the characteristics of the industry as a whole and of the companies that comprise it are largely unchanged. A recent survey conducted by the Engineering Research Center for Net Shape Manufacturing at The Ohio State University characterized the industry with respect to the company size, business volume, typical lead times and products [22].
One characteristic prevalent within the die and mold manufacturing industry is that change occurs slowly. Decision makers are reluctant to make large investments in new technologies or procedures [21]. Significant changes are therefore often reactive rather than proactive, occurring only when market pressures make it increasingly difficult to compete using the existing technology and methodology.

In summary, the objective of most of the research in die and mold manufacturing has been to improve either the performance of the die or mold or the individual processes used in fabricating them. While gains are realized with each leap in technology, technological and process constraints will always limit the time required to physically produce a die or mold. The theoretical minimum boundaries for lead time have not been determined, and in most cases could not be achieved because of other constraints. Consequently, strategies to reduce the lead times of dies and molds must include not only technological approaches, but also process approaches which target the organizational structure of the die or mold manufacturing organization and the interactions with other organizations.

2.2 Literature Review

2.2.1 Customer-Supplier Relationships

The relationship between customer and supplier is the basis for a dependable supply of high-quality inputs to the customer's business. One focus of the literature on customer-supplier relationships is the creation and
maintenance of a supplier qualification program. For the most part, these approaches assume that the buyer has the power in the relationship and direct the buyer on how to evaluate and negotiate with potential suppliers to their advantage. Suppliers benefit from this information primarily from the insights they gain regarding the expectations of their potential customers.

The new strategies of product development call for partnerships with suppliers. The level of commitment between the organizations depends on the complexity and degree of customization of the product [23]. Conventional, antagonistic relationships are appropriate for standard items, with price being the primary factor in choosing a supplier. When the technical requirements are greater, an association is formed in which the supplier is consulted in advance of the order and the contract is long term. The basis for a selection then includes not only costs, but also an evaluation of the supplier's process capabilities, systems and management. In the extreme, partnerships are needed when there is a requirement that the supplier be involved with the development and planning of the product to be assembled and/or marketed by the customer's organization.

In these so-called buyer-supplier partnerships or strategic alliances, the supplier is integrated into the customer's information and planning process. The buyer shares more information with suppliers about long term plans [24]. The organizations work together to make improvements to the product, and the supplier shares responsibility for solving problems in customers'
organizations related to the component or other input that they supply. The suppliers' overall strategies are now a key factor in the supplier selection process, and are evaluated in addition to the factors previously mentioned. The customer may take responsibility for developing the technical capabilities of the supplier [25], and will commit a larger share of business to the supplier [24]. Suppliers also benefit by knowing their resource commitments well in advance [26]. One of the potential benefits of early supplier commitment to both parties is that the non-value added activities in the interaction can be identified and eliminated [27].

Ellram conducted an investigation to discover the reasons that firms form buyer-supplier partnerships, and the factors that determine success and failure in these relationships [28]. The primary reasons that buyer firms enter strategic alliances with their suppliers include control over costs, supply reliability, the desire to improve supply quality, greater ability to control delivery schedules, access to suppliers' capabilities, and the ability to reduce procurement costs.

Suppliers enter alliances primarily to ensure a stable market for their products. Other, significantly less important reasons include the desire to influence the buyer's quality and support their just-in-time (JIT) practices, having the ability to improve planning by being better able to forecast resource

\[\text{Importance here is based on the suppliers' ranking of the factors as reported in the study cited.}\]
usage requirements, and the reduction of sales and marketing costs. Having the ability to influence the customer's technology was the least important factor for establishing a long-term relationship.

According to buyers' perceptions, the factors which most influence success of a purchasing partnership are information sharing, support of top management, shared objectives, early communication with suppliers, and the value added by the distinctive capabilities of the supplier [28]. The suppliers shared these views, and also found that total quality management (TQM) and just-in-time (JIT) initiatives were also important in ensuring success. Not surprisingly, factors detrimental to strategic partnerships are poor communication, lack of trust, absence of shared goals, poor initial planning, low status of importance of the players in the customer's organization, lack of benefit/risk sharing, insufficient commitment on the part of the supplier, and a perception that there is no distinctive value offered by the supplier.

Stuart and McCutcheon investigated the difficulties in implementing buyer-supplier partnerships [24]. Their study found that difficulties arise when the supplier perceives that the buyer has little to offer in return for the supplier's high level of commitment. Failure of the customer to meet supplier expectations because of reluctance to share information, solve problems jointly, or share the benefits gained from the alliance can destroy a partnership. Such outcomes reinforce suppliers' innate suspicions of customers who desire an extensive commitment.
Both of the studies discussed above were conducted using surveys administered to both buyers and suppliers who were involved in strategic partnerships [24, 28]. Both the customers and suppliers came from a range of industries, with the supplied products ranging from commodity items including standard maintenance and operating supplies to industrial equipment to made-to-order items.

2.2.2 Supplier Involvement in Product Development

Market pressures for a larger variety of consumer products has led to shorter product life cycles and more frequent product introductions. Time has become a primary competitive weapon in manufacturing today [29-38].

One of the most effective strategies adopted in order to compress the product development cycle and quickly introduce new products to the market is simultaneous or concurrent engineering [30, 31, 36, 39-43]. This approach contrasts with the traditional phase-gate product development process. In theory, when a concurrent engineering strategy is used, all product development activities start at the earliest possible date and up-to-date information is available to all functional groups throughout the new product introduction process. In the traditional, phased approach each phase of the product development process is independent and is performed by a different functional group. The phases take place sequentially. Concurrent engineering is an attempt to optimize the process by removing the inefficiencies introduced at the interfaces between functional groups and when participants are forced to
work with incomplete information or repeat activities because decisions made during early design activities are incompatible with the needs of functional groups that are responsible for later tasks.

The literature in product innovation and manufacturing strategy contains recommendations regarding the composition and management of project development teams [29, 30, 33, 36, 38]. The project team, active from product conception through the start of full-scale production, is comprised of participants from all relevant functional groups. Progressive companies include suppliers and representatives from the intended market, as well.

Other strategies for accelerating product development include the faster phased approach, which has shorter phases with less time between them; a contingency approach used to select either the faster phased approach or the concurrent approach based on organizational needs and the degree of product innovation; also, new venture units and skunk works, in which the product development team is isolated from the rest of the organization, functionally becoming a separate organization during product development, and given extensive control over product development decisions [31].

Two studies have attempted to characterize and model the involvement of suppliers in product development. Birou [44] conducted a survey in order to identify suppliers' roles in product development in an integrated product development environment. The study attempted to determine whether supplier involvement affected cost, quality, product performance, and
development time, and to evaluate the impact of supplier involvement on overall project performance. Buyers' responses revealed that supplier involvement had a significant negative effect on every aspect of product development measured. These results were not expected and, using the available data, the author was unable to posit reasons for the findings.

Hartley [45] also investigated supplier involvement in product development. In addition to determining the extent to which supplier involvement affected the technical success of the product, the study sought to quantify the benefits that supplier involvement yields and to identify management techniques that are effective in joint product development activities. Many of the factors measured had no effect on the ultimate success of the product, in the buyer's view. Three factors were found to be significant: supplier proactiveness, interaction, and the frequency of written communications. Of these, only supplier proactiveness, defined as cooperativeness, openness to new ideas, and the ability to initiate suggestions for product improvement, had a positive effect. No effects on the development time were reported. The buyer's management techniques also had no measurable effect on the outcomes. Again, the reasons why buyer's perceptions were not favorable regarding suppliers' impact on activities that are typically the buyer's responsibility and under the buyer's control were not reported.

Three studies discuss the concurrent engineering of dies and molds [46-48]. In each of these studies, "concurrent engineering" refers to the parallel
performance or integration of activities within the die or mold manufacturer's organization after the product design has been finalized and released to the diemaker. Choi et. al. integrate CAD and CAM to handle dynamic product model data for die and mold organizations [46]. The data system contains a master model of product data which encourages some overlap of activities. The "concurrent engineering approach" described by Gerdes, Webb, and Chassapis is an expert system that generates detailed process plans for all mold components [47]. Mukherjee and Nof present a strategy for integrating die design and production activities [48]. A concurrent engineering team is formed; the team has two permanent members who are involved throughout all design and approval activities. The key in this strategy is a computer system that integrates information from what are typically separate activities to facilitate better decision making throughout the project.

The forming of partnerships with die and mold suppliers has been called for in the literature [5, 49-51]. Faughnder [49] predicts that both cost and lead time can be improved by such involvement, and lists several mold design factors that should be considered early during product design and reviewed with the moldmaker. Although the author acknowledges that mold projects do not often have a budget that accommodates extensive prior communication, he implies that the degree of confidence in the more robust design offsets these costs. Neto [50] suggests that reductions in lead time can be realized by early involvement of mold design and construction personnel. In addition to calling
for long-term partnerships between molders and moldmakers. Kleeman [5] enumerates several criteria by which moldmaker-partners should be evaluated prior to developing such a relationship. These include such factors as methods and frequency of communication with customers, the percentage of outsourcing, project management practices, the extent of services offered, and the benefits afforded to preferred customers.

2.3 Limitations of Prior Research

The literature review presented in the previous sections reveals several areas that have not been effectively addressed, and these holes in the literature base provided further justification for this research.

First, the survey methodology was used in most prior studies. This research technique is useful when assessing the nature of the environment being studied. Through judicious use of surveys to test the hypothesized effects of supplier participation in product development, the fact that this involvement is typically not felt to be advantageous was revealed. However, the methodology used prevented any conclusion regarding why the hypotheses were not supported, because the questions asked were not meant to elicit that information. Consequently, the results, which were unexpected, were not adequately explained.

Surveys were also used to characterize buyer-supplier partnerships, and to discover the motivations for forming and maintaining these relationships. Although these studies yielded insightful revelations, and in some cases
included matched pairs of buyers and suppliers, the firms were not
categorized well enough that it is possible to determine the applicability of
the findings to a particular industry or to conclude how factors other than
organization size effect the nature and success of long term alliances.

Previous studies were not able to assess differences that might exist
between industries, with respect to the extent and effect of supplier
participation in product development. Although one of the studies did
recognize that there were differences between the industries represented by the
companies surveyed, the number of respondents in each industry was
insufficient to draw any conclusions regarding the differences. Again, it would
not have been possible to determine the reasons for these differences using the
data collected, even with a larger sample.

Aggregate data is used for analysis in survey studies. Consequently, the
recognition and closer analysis of unusual or unique situations is limited and
the reasons for anomalies or unusual patterns in the data are masked.

Some other important questions were not answered by the previous
studies. The benefits and disadvantages of supplier involvement in product
development were not quantified.\(^7\) The specific role of suppliers in product
development was not identified. Are suppliers being included as consultants

\(^7\)Admittedly, this may be difficult to do in any study, first, because the data may
simply not be available, and also because, when available, the sensitivity of that data may
make firms unwilling to share it.
and advisers, or are they making decisions that may affect other functional groups? The manner in which suppliers influence decision making during product development was not addressed. The culture of organizations and/or industries, and how it affects the potential for successful supplier involvement in product development, was not assessed. In addition, the history between the customer and supplier and how it influences the success of the product development project was not addressed.

Previous studies on supplier involvement in product development have assessed only the effects on the buyer's organization. The supplier's point of view was not captured, and the effect on the supplier's organization has been ignored. Therefore, the suppliers' capabilities prior to the involvement in product development and how these capabilities were affected by the new requirements are not known. In fact, the information gleaned from those studies does not empower suppliers who wish to enter into these liaisons or ensure that they will be beneficial to both parties.

The literature that has addressed the early involvement of die and mold manufacturers focuses only on the benefits to the buyer. Although the general purchasing literature indicates that suppliers will not enter into such an alliance without clear benefits, neither the expectations of the die manufacturer in these extended relationships nor the concessions on the part of the customer that will be necessary in order to make the venture successful are addressed.
2.4 Contribution of this Study

This study will result in a better understanding of the interaction between die and mold manufacturers and their customers. The role that die and mold manufacturers play in product development, and the contributions that they are able to make with existing capabilities, will be understood. The manner in which increased involvement in the activities of customer organizations has affected the industry has been observed.

Knowledge regarding the factors that determine success and failure, the expectations and capabilities that are present in both customer and supplier organizations, and the skills needed in order to succeed in a partnership may serve as a planning tool. If manufacturers have a good understanding of what types of products die and mold manufacturers' influence can impact, when to get them involved, what role they can play, and how to best utilize their services over the long term, the obstacles and redundancies that now exist at this organizational interface may be eliminated.
CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

Fulfilling the objectives of this research was dependent on learning about the management strategies, product development practices, and behavior of individuals and organizations in the target population. Review of the research questions reveals that most of the variables of interest are qualitative rather than quantitative. This fact, paired with the underlying purpose of the research, theory building, was considered in selecting an appropriate research design.

Qualitative research methods are traditionally used in the social and behavioral sciences, including sociology, anthropology, history, psychology, education, political science and economics [52].

The contemporary research agenda in manufacturing and industrial engineering, as well as that in operations management, places more emphasis on the sociotechnical factors that influence production and manufacturing strategy than in the past, and thus requires an interdisciplinary approach to research. The application of qualitative research methods to areas of concern
in manufacturing, including operations management and control and information systems analysis, is relatively recent, and although it is increasing in frequency, has not yet become widespread [53, 54].

3.1 Choice of Research Design

The purpose of this research is theory building. The argument has already been presented that the previously posed theories regarding the involvement of suppliers in the product development activities of their customers have been tested and found lacking. The reasons for this are not well understood. The theory testing research in the extant literature has not provided any explanation why the theory does not hold in the tested populations. Nor has the theory been refined by specifying limitations on its generalizability or by placing boundaries on the relevant constructs. An alternative theory is needed. Developing such a theory, for one industry that possesses some unique characteristics, is the purpose of this research.

The use of multiple case studies was chosen as the research design most appropriate for this study. A case study, in the context of a research strategy, is an in-depth examination of a contemporary phenomenon by an objective, outside party who has little or no control over the events being evaluated [55]. The characteristics of a case study are 1) a focus on conditions at the time of observation, in the real-life context; 2) the researcher cannot manipulate the

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7 Historical data are used only for perspective and context development.  

25
situation; and 3) detailed planning of research is discouraged, and is typically not possible before data collection begins' [54, 56]. The case study is especially appropriate when the boundaries between the concepts and context are not clear [57].

When used for theory building research, case studies must go beyond a descriptive level. Although description will be important in sharing the reasoning used in developing the theory, a theory must, by definition, play an explanatory or interpretive role, as well [58].

Because the data collected in case studies document, in detail, the practices at the site(s) observed and the perceptions of the people involved, they provide a powerful basis for determining what the important factors are, how they are related, and why the relationship holds at those sites [53]. Case studies provide a means for capturing the complex, intangible, and emotional dimensions present in organizations that cannot be discerned through the use of mathematical models or methods that depend on aggregation of data [59]. In addition, unique attributes can be identified that may lead to greater understanding of the phenomenon being studied [60].

"...it is the anecdotal data that enable us to do the building. Theory building seems to require rich description, the richness that comes from anecdote. We uncover all kinds of relationships in our "hard" data, but it is only through the use of this "soft" data that we are

*This does not imply that there is little preparation needed before data collection, rather that there is some uncertainty on the part of the investigator as to what, exactly, will be discovered in the field.
able to "explain" them, and explanation is, of course, the purpose of research." [61]

The ability to make use of qualitative data is a strength of case studies. Note that a case study is not synonymous with qualitative research, although it is one strategy that can be used for qualitative research. Rather, it can make use of qualitative evidence. In fact, one of the primary strengths of the case study is its ability to make use of multiple sources and types of evidence.

Although it can be argued that a single, well-documented case study can provide the basis for good theory, the use of multiple cases plays an important role in determining the limitations of generalizability of the results [55, 56, 62]. The comparison of data collected at different sites allows for more rigorous data analysis and makes a stronger argument for the validity of the resulting theory [55].

The term "multiple case study" implies only that more than one case will be included in the study. It does not specify what a "case," the unit of analysis, is. It can be a person, project, department, organization, or some other entity that is clearly defined. Case studies also allow for the use of an embedded research design, in which, for example, more than one program or project at each organization studied is used as a unit of analysis, with the organization itself being a unit of analysis, as well. This type of design further strengthens the research by allowing for analysis of differences between not
only different organizations, but also different activities within the same organizational context [55].

3.2 Research Methodology

There are many criticisms of case study research that have been made in the literature, as well as steps that can be taken to address them [55-57, 62-67]. These arguments and suggestions were considered in performing this research. Another area of concern is the methodology used for the analysis of qualitative data. Several strategies have been presented in the literature that have offered guidance in this work (see, for example [55, 64, 68-70]). This section summarizes the approach that was used in this study for planning and executing the participant selection and data collection.

3.2.1 Case Selection Strategy

The objectives of this study and the research questions being addressed defined the population from which cases were chosen. Because the effects of buyer-supplier collaboration during product development are being evaluated, organizations from the die and mold manufacturing industry have been chosen as cases for this study.

This population has a broad range of characteristics that may be addressed, including, for example, company size, primary market industry, product type, utilization of technology, and innovation. It was necessary, within the cases selected, to represent a sufficiently broad range of these characteristics so that the contexts represented by the participants would be
familiar to a large cross-section of the industry. At the same time, the number of unusual attributes possessed by any single participant had to be few and well documented [62].

For this study, the key dimension along which cases were chosen is the primary product line. The goal was to have at least one organization in each of the following product categories: die casting dies, injection molds, sheet metal stamping dies. This choice of breadth in the product line encompasses several other dimensions, including company size, average lead time, and product complexity.

Companies that produce sheet metal stamping dies tend to be larger than those producing either die casting dies or injection molds [22]. With respect to lead time, the majority of injection molds are delivered in 10-20 weeks. Die casting dies average 10-20 weeks lead time, with a significant portion requiring 20-30 weeks. Of the products included in the survey, only sheet metal stamping dies had a large percentage that require greater than 30 weeks for production [22]. Sheet metal stamping dies and sheet molding compound (SMC) molds tend to have the largest physical size. Injection molds and die casting dies produce more complex parts.

A second dimension was the ownership of the facility; representation from both captive and independent shops was desired.

The goal for the total number of companies to be included in this study was between four and six. The requirements for both product and ownership
could be met with that number of participants. In addition, it met the guidelines provided in the literature that the number of cases be no fewer than four and no greater than ten [36].

3.2.2 Case Selection

Ultimately, ten organizations that manufacture dies and molds were included: four manufacturers of sheet metal stamping dies (including dies for both automotive body panels and black metal stampings1), two manufacturers of die casting dies, one manufacturer of injection molds, one manufacturer of molds for glass containers, and two manufacturers of SMC molds. In addition, one caster was included in the study. Two other casters were interviewed informally during one of the site visits.

Of the first five companies that agreed to participate in the study, three were manufacturers of sheet metal stamping dies. When the differences between the business environments faced by different segments of the industry began to emerge, it became clear that greater representation was needed from

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1"Black metal" refers to parts that are not visible in the finished product; surface finish is not a critical feature for black metal components.

1In the die casting and molding industries, die or mold manufacturers are seldom chosen by the OEM. Interaction between the OEM and die manufacturer typically takes place only with the approval of the parts manufacturer (caster or molder). The caster was included in order to gain some insight regarding how the OEM's expectations affect the services required of the die manufacturers. Two die casters that were customers of one of the participating firms were interviewed informally during a site visit. Although only one 'customer' organization was formally included in the study, it should be noted that respondents from the organizations having captive tool rooms included personnel from both the die or mold shop and from (internal) customer groups that interact directly with (external) customers.
other industry segments. Several additional participants were identified because many of the firms were able to provide only one respondent. Consequently, the number of participants is greater than planned. The final two interviews conducted confirmed what had been previously learned and yielded little new information. This is an indication that theoretical saturation has been reached, and a signal that data collection should cease [56, 66]. Data analysis may later indicate the need for additional data.

A contact person(s) was identified at each company that was targeted for participation in the study. This person was contacted via telephone and asked if they would consider participation. They were then sent a letter of introduction and a description of the project which outlined the scope and purpose of the study and what their participation would entail (these documents are included in the appendix). A copy of the dissertation was promised to each participant.

All of the companies were told that a nondisclosure agreement could be utilized as a condition of participation if they had any concerns regarding the use of information that could be considered confidential or business sensitive. Only one of the participating companies required a nondisclosure agreement. One company that was contacted refused to participate in the study.

Additional details regarding the participants is provided in the Chapter 4.
3.2.3 Data Collection Strategy

One characteristic of case study research is that there is no way of knowing, specifically, what data will be collected from each site. The data available is largely dependent upon the context. Having a protocol, or framework, for data collection can provide a filter for data. Instead of collecting all information possible at each case site, data collection is limited to those items that are important with respect to the research problems. Although use of this strategy can make the researcher's job easier, it is possible that relevant information that was not known in advance to be important can remain undiscovered. To guard against limiting discovery of relevant information, the protocol is used as a guideline for the minimum data to be collected, rather than as a checklist for completion. The framework is tentative. It is expected to change, and it is probable that what is learned during the initial data collection will reveal the need for different or additional data at the remaining sites [63, 71].

A structure for data collection guarantees that the data gathered from the case sites will be coherent. The same information need not be gathered at each site. However, the data collection structure does enable the comparison of similarities and differences among the sites, adding a dimension of analysis that provides further insight in refining the developing theory [53].

For this purpose, a list of questions to be asked of informants in loosely structured interviews was compiled. The questions were meant to be open-
ended prompts for gathering both facts and respondent's opinions. The use of such a data collection method allows the researcher to probe further when surprises are encountered, increasing the probability that the resulting theory will be useful and well-grounded, and will contain relevant factors that may otherwise have remained undiscovered [72].

On-site interviews were chosen as the primary means of data collection. The use of researcher as the data collection tool, rather than a questionnaire, even one having open-ended questions, is important. First, it allowed the questions to be tailored to the person being interviewed. Second, since the investigator is familiar with the purpose of the study and the research questions being addressed, it was possible to eliminate any ambiguities that the questions may have raised; improving the validity of the data. In addition, the interviewer is able to capture subtleties in the responses that are not contained in the verbal replies.

The goal was to have two or three respondents from each participating organization. Multiple sources of information allow for confirmation of data, and provide breadth from people serving in different roles and having different perspectives.

All of the interviews were tape recorded. When the researcher/analyst is the data collection instrument, there is a tendency for those data that add credence to the tentative theory that is being formed during data collection to be remembered and given more weight during analysis. When verbal data are
recorded, it is less likely that data that refutes assumptions will be ignored. It also minimizes the probability of oversimplifying or reinterpreting data in the light of more recent data, which are also commonly given more weight [64].

In addition to interviews, data was obtained from any accessible documents provided by the respondents that could further characterize their company, the expectation of their customers, or the relationships they had with customers.

3.2.4 Data Collection Procedures

The respondents at each participating company were chosen by the contact at that company. Although it was clearly indicated in the initial communications that it was preferable to have more than one respondent, several of the companies provided only one respondent. Often, that person was in a high administrative position.

Each interview began with a briefing regarding the nature of the study and disclosure of how the data would be used. Participants were required to sign a consent form. An interview protocol was used as a guide for the conversation. Each of these documents is displayed in the appendix. The interview protocol was typically not followed precisely. If it became clear that the respondent did not have knowledge in a particular area or that the context was irrelevant given the respondent's role, questions were skipped. Many of the questions asked were for the purpose of clarification or to probe further
based on previous responses. Any documents provided by the participants were to be returned to them at the end of the study.

After the site visits, the next contact with participants was to send them the company descriptions that would be used in this document in order to define the scope of the study. The description was sent to a primary contact at each participating company (or additional persons if that was agreed upon earlier). Any questions that remained after analysis of the original interviews were asked during a follow-up phone call. The company contact typically gave verbal approval of the document, or specified changes that needed to be made as a condition for approval.

3.2.5 Concerns Regarding Data Collection

Most of the interviews were very productive and the respondents were cooperative and shared information openly. In a small number of cases, however, it was clear that the respondents were actively judging the motives of the researcher during the interview, and sometimes were hesitant to share information that might make either their firm or that of a primary customer appear unfavorably.

In some instances the respondent's reluctance was communicated in a subtle manner. In other cases, they would share particularly relevant information and then qualify that "you can't talk about this," "you can't share this," or "this is not for publication." One respondent did not make direct reference to any companies other than automotive customers (the "Big 3").
throughout the interview. Most of the respondents that were reluctant to talk about customers or competitors\textsuperscript{11} were much less guarded when they were reminded that no individuals or firms would be named in any published reports of the study.

### 3.2.6 Data Analysis

Each respondent was assigned a random number; the tapes from the interviews were transcribed. The interview transcripts were then sanitized to remove direct references to the firm or individuals. The list of questions and the answers to them covered in any follow-up phone calls were later appended to the original interview transcript. The resulting transcripts were printed and used for analysis.

The interview transcripts were separated by industry segment\textsuperscript{12} and analyzed as a group. This way, the analysis was conducted on each group in order to characterize the industry segments. None of the firms was analyzed as an individual unit. However, the characteristics of individual firms were considered when unique data that stood apart from the rest of the group was discovered. This was necessary in order to determine what might be responsible for these anomalies.

\textsuperscript{11}Typically, sentences were prefaced with "I don't want to say who" or "I don't want to say what."

\textsuperscript{12}The industry segments are defined in Chapter 5.
In order to bring meaning to the masses of data that were collected, several frameworks and strategies discussed in the literature were utilized to structure segments of data and discover the underlying structures present [68, 69].
CHAPTER 4

DESCRIPTIONS OF THE PARTICIPANTS

This chapter contains short descriptions of each of the companies that participated in the study. These descriptions define the context of the study.

It is not the purpose of these narratives to analyze the companies, either to critique their performance nor to extol it. Rather, the descriptions offered are meant to summarize the characteristics of the organizations, from information that was gathered from the respondents in the firms during on-site interviews.

Because each of the participating organizations was guaranteed anonymity, specific data are not included. For a number of the companies that are in focused, highly competitive market segments, facts such as the location, company size or business volume would identify the company. The tables in the next section summarize statistics on the participating companies and the respondents.

The information included in these descriptions is meant to profile the firms. The information includes the primary product line, type of ownership,
the services marketed by the firms, tasks performed in-house and subcontracted, the customer base, marketing strategies, competitive environment, and the key competitive advantages of the firms. The descriptions were compiled from data provided by the respondents and were approved by a representative(s) in the firm as being accurate and appropriate for publication.

4.1 Overview

The data collected consists of twenty-two interviews conducted with twenty-three respondents at a total of ten die and mold manufacturing firms. In addition, any printed materials provided by the participants were considered. These items included documents used for marketing purposes, such as brochures or facilities and equipment lists; as well as sample documents stating customer's expectations of their suppliers, or the supplier's understanding of customer expectations in a particular program.

Each of the companies has been assigned a code name which identifies its primary market. Each code consists of one or two letters and, when necessary, a number that differentiates firms within the same market. Table 1 shows the codes for the industry segments represented. The number of companies and respondents from each group is summarized in Table 2.

In addition to the respondents listed, three interviews were conducted in a casting company. Two informal interviews were conducted with persons from casting companies that were customers of one of the participating firms.
Two of the die shops are captive to manufacturing companies and supply dies only for facilities owned by their parent company. A total of seven of the twenty-six respondents represent either firms or company divisions that are customers of the die shops.

Table 2. Distribution of companies and respondents in the study

<table>
<thead>
<tr>
<th>Market</th>
<th>Number of Companies</th>
<th>Number of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheet metal dies, automotive body panels</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Sheet metal dies, other</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Glass molds</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SMC molds</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Die casting dies, injection molds</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
The primary market serviced by the companies is automotive. With the exception of G and I.M., at least seventy percent of each firms' business is for the automotive industry. These companies are both first and second tier automotive suppliers. All of the facilities are located within five hundred miles of Detroit.

The respondents represent a number of functions within the firms, from shop floor supervisor to president. The distribution of the respondents by title or function is given in Table 3.

<table>
<thead>
<tr>
<th>Title or Function</th>
<th>Number of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>President, Vice President</td>
<td>4</td>
</tr>
<tr>
<td>General Manager or Program Manager</td>
<td>7 (4)*</td>
</tr>
<tr>
<td>Sales</td>
<td>1</td>
</tr>
<tr>
<td>Other functions**</td>
<td>7 (3)</td>
</tr>
</tbody>
</table>

* Numbers in parentheses represent respondents from customer organizations

** Other functions include engineers, designers, persons in quality and prototyping, and shop floor supervisors

Table 3. Functions represented by respondents

The automotive industry here includes passenger cars, trucks, and heavy trucks.
Both captive and independent shops are represented. The captive shops are divisions of first tier suppliers. Of the independent shops, a variety of ownerships are represented. Table 4 summarizes the ownership of the die manufacturers included in the study.

All of the die manufacturers use NC machines in their manufacturing facilities. All of the companies provide design of the tooling as a service to their customers. Most of the firms do their own die design in-house unless designs are provided by the customer. Only two companies outsource all of their design work. Three others outsource portions of their die design. All of the organizations maintain CAD capabilities as required by their customer base. All but three of the companies do all of their design work in solids

<table>
<thead>
<tr>
<th>Firm Type</th>
<th>Number of Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Captive&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2</td>
</tr>
<tr>
<td>Family owned business&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2</td>
</tr>
<tr>
<td>Individual owner</td>
<td>2</td>
</tr>
<tr>
<td>Publicly traded company</td>
<td>2</td>
</tr>
<tr>
<td>Division of a larger corporation having other product lines</td>
<td>4</td>
</tr>
</tbody>
</table>

<sup>a</sup> these categories are not mutually exclusive
<sup>b</sup> a shop is considered captive only if the majority of product is used in-house
<sup>c</sup> currently operated by 2<sup>nd</sup> generation or later

Table 4. Ownership of participating firms
whenever possible; and of the others, two indicated an intention to acquire this capability in the near future.

The relative size of the companies is defined using staffing levels or annual business volume. The ranges for each of these factors are summarized in Tables 5 and 6.

A range of characteristics of firms in the die and mold manufacturing industry is represented by the firms that provided data for this study. Two categories are absent. One is made up of the very small operations often referred to as “garage shops” or “mom and pop shops.” These shops typically have low overheads, manually operated equipment, and very few employees. Often, such organizations are in the third, fourth, or lower tiers of the manufacturing supply chain, and are supplying simple tools or components. The likelihood that these companies will be involved in design or product development, or even interact with the assembler, is small. Consequently, no

<table>
<thead>
<tr>
<th>Number of Employees</th>
<th>Number of Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 50</td>
<td>4</td>
</tr>
<tr>
<td>50-100</td>
<td>1</td>
</tr>
<tr>
<td>100-200</td>
<td>3</td>
</tr>
<tr>
<td>&gt; 200</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 5. Number of employees in participating firms
<table>
<thead>
<tr>
<th>Annual Business Volume</th>
<th>Number of Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; $10M</td>
<td>3</td>
</tr>
<tr>
<td>$10M-$25M</td>
<td>3</td>
</tr>
<tr>
<td>$25M-$40M</td>
<td>2</td>
</tr>
<tr>
<td>&gt; $40M</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 6. Business volume of participating firms

attempt was made to include participants from this segment of the industry.

The second unrepresented segment of the industry is the automotive companies' captive shops. These tend to be the largest die shops; and typically produce only sheet metal stamping dies for auto body panels.

The range of characteristics represented by the participating firms has been presented in this section. The sections that follow provide a closer look at the die and mold manufacturing companies. The casting company that provided data will be briefly described in the section on the die casting die market in the next chapter.

4.2 The Companies

4.2.1 D1

D1 is an independently owned engineering and manufacturing company whose primary products are die casting dies and molds.
D1's customer base consists primarily of casters that supply the automotive industry. Some of these casters do not have engineering capabilities or CAD systems to meet the requirements of their customers. D1 functions as the engineering department for these customers. In this capacity, D1 interacts directly with the caster's customers, and often hosts program meetings at their facility. D1's role is so integrated into the caster's activities that they refer to the caster's customer (their customer's customer) simply as "the customer." Behaving as a part of the caster's organization places an additional burden on D1 since they must downplay their prominent role in resolving design and engineering issues when representing their customers, in order to present a capable and seamless supply source to the caster's customer. Being able to perform as part of the team in providing design and engineering services makes D1 invaluable to customers, and for several they are a preferred tooling source, especially for technically challenging jobs.

Marketing at D1 consists largely of maintaining existing relationships and developing new ones. At D1 a high value is placed on developing personal relationships with individuals in customer organizations, and over the past two decades they have been able to build a customer base by nourishing those relationships.

Dies manufactured by D1 are primarily for medium-sized cast parts. Their work includes both single die and multiple die programs. D1 supports the caster's production activities by training customer's setup personnel on the
operation of complex dies and by maintaining tools that will allow them to quickly service or repair dies they have manufactured. Die design and related engineering activities are provided as a service, and are always performed in-house.

Gains in efficiency at D1 are the result of a deliberate attempt to eliminate the bottlenecks in their process. This has resulted in the development of standards and methods that have streamlined their up-front engineering activities. They are able to efficiently transfer electronic data, develop the cast model, quickly design the die or mold, and perform preliminary process analyses. Visual communications tools that display the operation of dies save time by ensuring that both internal staff and customers share the same interpretation of the finished product.

The improvements in efficiency have been the result of DI's vision, motivated by anticipating what customer's future needs will be before the market demands change. This strategy has led to the development of capabilities that allow DI to provide services their competitors cannot offer.

DI avoids working with competitors, in order to maintain their distinctive competencies. Rather than concentrating on the capabilities of their direct competitors when planning strategies, they focus on making sure

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14 May include flow analysis and identification of potential solidification problems.
that their customers stay competitive, thus ensuring a stable source of future
work.

4.2.2 D2

D2 is an independently owned manufacturing company whose primary
products are die casting dies. Of die casting die manufacturers, D2 is of
average size. However, the company has been growing and, in fact, their
business volume has increased almost twenty percent over the past year. They
are in the process of becoming QS9000 registered.

D2 has been in business just over ten years, and has a workforce that is
relatively young. Much of the growth they have experienced has been possible
not because the size of the workforce has increased significantly, but because
they have gained efficiency as the training of their staff progresses. Improved
efficiency is also realized on repeat orders from regular customers. The savings
realized due to performance improvements are often passed on to customers in
the form of a refund.

D2 makes dies for parts in a large range of sizes, and for a variety of
customers. About eighty percent of business is for the automotive industry. A
large percent of the remaining volume is for customers that produce household
appliances and lawn and garden equipment.

In the past, marketing activities have consisted primarily of doing a good
job in order to ensure repeat business from existing customers. This has
allowed D2 to establish blanket contracts with some customers to fill all needs
for specific products. They now also have someone performing a marketing function in order to help secure work to fill the additional capacity that is available due to gains in efficiency.

Most of D2's orders are for single dies. They also manufacture many replacement inserts and do repair work. All of the design and engineering work associated with the dies is also provided as a service. In addition to manufacturing dies and die components, D2 also does some specialty machining. They are considering expanding their product line to include such items as small stamping dies and molds for plastics. The strategy would be to concentrate on additional services and products that can be provided using the existing resource base.

Typically, only very large boring mill and grinding work are outsourced. Outsourcing is purposely kept to a minimum. However, some other machining and construction activities may be outsourced when delivery requirements cannot be met using internal capacity. Design and engineering are always performed in-house.

D2 has good relationships with several of their local competitors. The companies will help each other when their workload exceeds their internal

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17 It is common for die casting dies to be ordered in lots of as many as twelve or sixteen.

18 Repair work accounts for about 25% of the total business volume.
capacity. D2 has even assisted competitors by helping to train staff on new technologies at the competitor's facility, at no cost.

One of D2's primary management philosophies is that one of the best things they can do is ensure the success of their customers. They strive to always keep the customer happy and to meet both the expressed and unexpressed needs of customers. It is not surprising, then, that they attribute their success in large part to the strong relationships that they have been able to build with their regular customers over the past decade. Other factors which have been essential include the synergy that creates a feeling of family among the workforce and investing in technological advances that can improve efficiency.

4.2.3 IM

IM is a family-owned business that is both a molder and an average sized manufacturer of injection molds. Now in its third generation of management, IM has been doing business for nearly five decades. For the past five years, IM's business volume has been growing nearly twenty percent per year.

IM produces molds for the medical, housewares, electronics, sporting goods, cosmetics and automotive industries. About one third of their business is for the automotive industry. The parts they are building molds for are relatively small; most can be held in the hand.

Roughly ninety percent of the molds are built for domestic molders. The remaining molds are for use in their own production facility.
Marketing is primarily by word of mouth, and a focus on getting repeat business from existing customers. Many of IM's customers are first and second tier suppliers. However, some are OEMs, as well. For many customers, IM is a preferred source for molds, and will be used unless their backlog won't allow them to meet the customer's delivery requirements.

IM invests a great deal in highly accurate, technologically advanced equipment. As such, their pricing places them in a market for "high-end, technical molds;" complex molds with tight tolerances. The state-of-the-art equipment is considered key to their efficiency, as it allows them to build molds faster and more accurately. Vendors are the source of new technologies and processing strategies.

IM also provides engineering services. They design all of the molds that they build. They also do product design. For customers that come only with rough ideas, IM will design a manufacturable part, provide the customer with drawings, and have prototypes produced so that the concept can be verified before the mold is manufactured. Upon approval from the customer, they will build the mold and produce the parts.

Other services include the sampling and debugging of all molds. Sample parts are approved by the customer before the molds are shipped. The processing parameters are also provided to the customer so that they have a good idea of where to start when proving out the process in their own facilities.
Activities that IM usually subcontracts include prototyping, finite element analysis, any type of plating, most lathe work, and some polishing. Finite element analysis is typically performed only on designs that were generated in-house, when there are specific areas of concern that the customer has been alerted to. Generally, the work outsourced requires capabilities that are not present within IM because the demand for them is not great, or for which it would be difficult to justify additional capacity in-house.

Management activities have been simplified by the use of custom software that IM has had developed for scheduling and quoting activities. The rapid growth experienced in the company has presented a challenge requiring a greater dedication to management activities. The only visible way in which customers have affected internal management procedures is through the market demand for QS9000 registration, which IM is currently completing.

4.2.4 G

G, a manufacturer of molds for glass containers, is the mold division of one of the three large manufacturers of glass bottles in the U.S. As a captive mold supplier, G accepts mold orders only from within other divisions of the company.

G has historically manufactured all of the molds needed within the company. However, due to recent organizational changes, their current capacity is not sufficient to meet all of the corporation's needs, and some mold
production is outsourced. Current plans are to expand the capacity within G's facility in order to meet the increased demand.

The products that G makes molds for include a variety of glass containers. The largest percentage of customers\textsuperscript{17} come from the beer, beverage and liquor industries. However, containers for food products and consumer products are also included in the product line. Molds are manufactured both for new products and to replace molds for items already in production. These, in turn, include both standard items and specialty bottles which have been designed for a particular customer and product.

On average, a lot size of fifteen or thirty molds is manufactured for new products. Fewer molds are produced for specialty bottles that will be manufactured in small quantities. Replacement molds and mold parts are produced on an as-needed basis.

During development of a new product, the only task which is always outsourced is prototype production. A single source is used for prototypes. Excess mold production is sent to a single external source, since there is only one large independent manufacturer of molds for glass containers in the country. G has a good relationship with that company, and has, on occasion, consulted the shop when implementing a new technology within their own

\textsuperscript{17}Here, "customer" refers to customers of the corporation, and not of the mold division directly.
facility. Decisions on whether to have a mold produced in-house or outsourced are typically made at the corporate level.

Castings are procured from an external source and some specialty machining is outsourced. Other than that, all of the activities needed to manufacture the molds are performed within G's facility. The initial process decisions including the parison (or preform) and layout design are generated at the corporate office by personnel in the New Product Development department. Most of the needs of the mold division are addressed during that process, because the New Product Development department includes several persons who were previously with the mold division. They were transferred to the corporate office to ensure that any issues concerned with the manufacture of the molds would be addressed during product design, process selection, and mold design. The final design and detailing of the mold equipment takes place at the mold division.

G interacts primarily with the New Product Development staff at the corporate office and with the development plant. Orders for replacement molds come directly from the production plants. In addition, there is occasionally some interaction with the prototype house and the external mold builder, primarily for the purpose of resolving ambiguities in the interpretation of designs for complex new products.

18 Tryout and debugging of molds for new products is performed at the experimental and development plant.
As a fiscally independent unit of the company, G is expected to be profitable and to have costs which are competitive when compared to the independent mold source. The primary advantage of keeping mold production at G is the ability to have jobs completed quickly and to prioritize molds for new products in order to meet customer's tight new product introduction schedules.

4.2.5 S1

S1 manufactures large automotive sheet metal stamping dies. Die sets for most major sheet components are included in the product line. However, Class A panels, including doors, trunks and hoods, are the primary focus. S1 is an independent, family-owned business, and is somewhat larger than average among automotive stamping die manufacturers.

S1's customer base consists primarily of the domestic automotive manufacturers and their first tier suppliers. The Japanese auto companies have been occasional customers as well.

The services S1 provides to customers include process development, prototyping, and the design, fabrication, assembly and tryout of dies. Of these, prototyping is the only activity not supported within their facility. Die design in solids is performed in-house, while other design activity is outsourced. Machining of die components is outsourced when delivery schedules cannot be met with internal capacity.
Tryout capacity at S1 exceeds their die build capacity; and so they often perform tryout of dies built in their customer's captive die shops. On-site support during tryout at the home plant is also offered as a service.

S1 attributes their continued success to investments made in facilities and personnel. A primary strategy has been to identify the most time and labor intensive tasks in their die manufacturing activities and to systematically find ways of shortening or eliminating those activities. This approach has led them to alternatives beyond just doing the same things faster. They have changed the way in which they both manufacture and try out dies.

Customers are sometimes reluctant to allow use of these unorthodox approaches. By guaranteeing customer satisfaction and refunding the savings realized to the customer, S1 has been able to get support from their customers and to change their expectations. Customers have even begun to use S1's strategies in their own die making facilities.

Immediate financial benefit is not the sole criterion for investment decisions made at S1. Instead, a focus on the efficiency of the entire facility rather than on individual functions has been the driving force for decision making.

S1 considers its primary competitive threat to be foreign die manufacturers that compete primarily on pricing when there is little business available in their home regions. The most aggressive of these competitors are
from Japan, Southeast Asia, and South Africa. Among domestic die manufacturers, S1 does not consider any a serious competitive threat.

By consistently improving efficiency and delivering a high level of service, S1 has been able to maintain stable levels of business from their customer base. They are now a preferred source for their primary customer and are notified of future work as much as 3½ years before the delivery dates.

S1 is competitive with respect to pricing and delivery. What differentiates them from their competitors is the additional service they can provide when customers give them the opportunity to have input into the process and are willing to use their expertise in identifying product features that will cause problems during both tool build activities and production.

4.2.6 S2

S2, a division of a privately held manufacturing corporation, is a manufacturer of sheet metal stamping dies. Companies that make stamping dies tend to be the largest in the industry, and S2 is large relative to many of its direct competitors.

Parts that S2 most often provides dies for include automotive outer body panels and the associated inner, structural components. Dies for other automotive sheet metal parts such as floors and fuel tanks are also manufactured.

The domestic automotive industry is responsible for the bulk of S2's business, with appliance and furniture industries as occasional customers.
Currently, S2 is trying to market their business globally, primarily in Europe, Asia, and South America. The target foreign market consists primarily of the foreign affiliates of domestic automotive manufacturers. Consequently, competitors that are considered most threatening are those that have a reputation worldwide and market globally.

S2's customer base includes the automotive companies as well as their first-tier and second-tier suppliers. Competitors include other independent die shops, shops that are captive to first-tier suppliers, and shops captive to the automotive companies. The automaker's captive shops are considered the least threatening in terms of competition and, in fact, are often viewed as customers or partners rather than as competitors.

S2 performs a number of services other than die construction, including the initial proving out of the process in soft tooling, analysis, prototyping, design and build of the dies, tryout, die qualification, and on-site support during the installation and initial tryout of dies at the customer's production facilities. The most desirable programs will include responsibility for both automation and assembly equipment. The delivered product includes not

"Die qualification may include a pilot run of as many as 200-300 parts.

"Currently, S2 markets dies and assembly equipment and sells the entire package whenever possible. This report addresses only those activities directly involved with the dies. However, it should be noted that because of the involvement of personnel that are responsible for the specialty equipment, it is likely that concerns for material handling during assembly may be considered during die design and other up-front engineering activities to a greater extent than in competitor's organizations.
only a die having a limited guarantee, but also specification of the process parameters that will produce high quality parts. Additional services that have been provided to customers upon request include the training of personnel from the production plants and the involvement of a team of S2 personnel during not only installation and tryout in the home plant, but also during ramp-up to full-scale production.

The qualities that most differentiate S2 from their competitors are their ability to handle a number of large programs, the extensive die tryout capabilities, and the ability to provide both dies and automation and assembly equipment from a single source. Capacity for die tryout is such that it is not unusual for S2 to perform die tryout for tooling that has been fabricated elsewhere.

Outsourcing is an important part of S2's business, and relationships with several smaller shops in the region are considered affiliations or partnerships. These affiliates are depended upon to provide additional capacity for many of the functions performed in-house. In fact, their ability to handle a number of large programs depends on maintaining good relationships with these other companies. Some of the partnering firms would be able to compete with S2 for jobs, but prefer not to work directly with the automotive OEMs.

\[2^{1}\] In the past, this may have been a group of as many as a dozen people who were at the customer's facility for a month or more.

\[2^{2}\] Although the dies may have been built by a competitor, tryout at S2 is typically performed at the request of a customer.
The specific tasks that are contracted out are chosen strategically, such that the work comprised of what S2 considers its core capabilities remains under their control. Machining of die components, assembly and preliminary tryout of smaller dies, or dies for less critical parts, may be outsourced. The larger dies, those with class A surfaces, and all of the design engineering tasks, are typically kept within S2. All subcontracted work is managed and continually monitored by S2 personnel.

S2 considers cost, quality, and on-time delivery equally important in terms of remaining competitive and servicing customers. Of these, delivery is often the most challenging goal to meet, because of the number of changes that often come from customers late in a program. S2 competes primarily on quality and reliability, and prides themselves on delivering dies that will stamp high-quality, production-worthy parts within hours of installation in the production facility. Pricing is considered competitive, although it may be somewhat higher than that of shops captive to automotive suppliers.²⁷

S2 has a team responsible for continuous improvement within their organization. At the completion of each program, a representative from continuous improvement meets with staff who were involved with the project. Their objective is to evaluate all aspects of the program and to identify specific

²⁷It is widely assumed that captive shops affiliated with the automakers get business primarily because of union agreements that guarantee a minimum percentage of available work. Shops that are owned by supplier organizations often quote a lower price on the tooling, and recover any losses from the profits made in their parts production.
ways in which future programs can be improved. A conscientious effort is then made to implement these improvements in future programs. Currently, S2 is considering how to incorporate customer feedback into this post-completion program evaluation process.

New management strategies have focused on meeting and exceeding the expectations of customers, investing in technology, and competing in the global marketplace. These aggressive measures have turned S2 around from a low point characterized by poor performance several years ago to a point where they are now profitable, praised for their quality, and attest to over ninety percent on-time delivery. They are also a preferred die source for their primary customer, who is currently responsible for about eighty percent of their annual capacity.

4.2.7 S3

S3 is a captive supplier of sheet metal stamping dies and assembly equipment. S3 supplies production tooling to a company that manufactures automotive stampings and assemblies. All of the stampings are black metal components.

Internal capacity is not sufficient to meet all of the company's production needs, and a portion of the die design and build activities are outsourced. The die group has limited interaction with customers. However, they do have

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24 Not described quantitatively by respondents in S2, but acknowledged by them to have been recognized by both employees and customers.
opportunities to provide input into process definition and component design decisions.

S3's primary asset is the competitive advantage it gives to the company. The ability to expedite critical jobs allows the company to meet demanding schedules. This would often be impossible if external tooling sources had to be used.

4.2.8 S4

S4 is a manufacturing facility that has a focus on sheet metal stamping dies. This tool and die plant is one division in a large conglomerate.

Most of S4's business is with the automotive industry, with first tier suppliers to the domestic automakers being the primary customer base. S4 manufactures dies for a wide range of sheet metal components, including automotive body panels, body side apertures, and the black metal underbody parts.¹⁷

Other services S4 offers to customers as part of its die build programs include die design, prototyping, and computer-based process analysis; all of these are typically outsourced.

S4 has very large presses in their tryout area, and their tryout capacity exceeds their die build capacity. Tryout of dies built by competitors or customer's captive die shops is performed as a service. In addition, tryout

¹⁷S4 has a preference for black metal parts, because the surface finish requirements are not as severe, and handling of parts during sampling is easier.
presses are on occasion used for short production runs, such as service stamping and factory assist stamping.

In addition to selling complete die programs, S4 markets each of the skills that they maintain in-house as separate services to other manufacturing companies. These include machining, benchwork, and trvout. In this work, S4 often performs job shop activities on products other than sheet metal dies. They also provide additional capacity for other die shops in the area that are loaded beyond their internal capacity. Rather than trying to be highly specialized and attempt to capture a large segment of the stamping die market, S4 is seeking other opportunities in specialty machining and production to utilize excess floor space and capacity within their facility.

4.2.9 M1

M1 is a manufacturer of SMC compression molds. An average-sized mold shop, M1 is part of a division owned by a large conglomerate.

The majority of molds built at M1 are for the automotive industry, both for heavy trucks and passenger cars. Roughly five percent of business is divided between the aerospace and housing industries. Most molds are for parts such as the hood, roof, doors, and air deflectors of trucks, and passenger car body panels. Household items would include products such as laundry sinks and floors of shower stalls.

Customers are comprised of domestic molders who are first tier suppliers to the U.S. plants of several automotive and truck companies. Although M1
quotes for new business with a number of molders, over two thirds of their
capacity is utilized by their primary customer. Because of a well established,
positive relationship with that customer, M1 is now a preferred source for that
company’s molds.

M1’s capabilities include most of the activities required to fabricate and
assemble the molds. However, because of limited capacity, a large percentage
of work is outsourced. Activities always performed in-house include assembly,
tryout, the final fitting and touch up, and checking for dimensional accuracy.
The strategy M1 uses when sourcing work is to identify and work with the best
in the business. By doing this, much of the control that might have been lost
by having work performed in outside facilities is preserved by using sources
that are expert at what they have been chosen to do. As a result of
administering these activities, M1 has become proficient at managing even
very large programs having very tight timing requirements.

Mold tryout is performed at M1. Personnel from the customer’s
company are paired with staff from M1, and a press is provided so that they
can test the molds and develop the process parameters that will be used in their
own production facilities. Another service occasionally provided is short
production runs of parts before the molds are shipped.

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\(^{20}\)This is an important service, since it enables the customer to do process development
without disrupting production in the home plant. Since the process development/tryout may
take as much as two days, this results in a tremendous savings to the customer.
The capability which most differentiates M1 from their competitors is their ability to provide evidence of the dimensional accuracy of the mold. This is done using a proprietary process which was developed by a team consisting of M1 and an automotive company. The analysis is performed on most molds, at their own expense. This added step enables M1 to identify and correct problems before the molds go into tryout. It also assures the customer that problems that arise are due to the process, and not to the quality of the molds.

It is evident that the management at M1 places great value on personal relationships with customers, and is willing to work with them within their constraints in order to assure the continued viability of both organizations. In spite of some difficulties realized by their division in recent times, the integrity of M1's personnel, their commitment to quality and competitive pricing have won them a committed customer base that has helped their mold business to grow and will enable their continued success.

4.2.10 M2

M2, a builder of large molds for both sheet molding compound (SMC) and plastic injection, is a division of a large, privately held corporation. M2

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27 The particular division of the company to which M1 belongs has other businesses besides mold manufacturing. This description has focused only on the mold portion of the company, which has a separate staff, and accounts for about thirty percent of the business volume of the division.

28 In the next chapter, M2 was included in the SMC mold market segment and not in the mold market segment, which includes manufacturers of injection molds. The majority of M2's business has been SMC molds for the past several years, and in the specific cases discussed, the customers were purchasers of SMC molds.
has a dedicated staff of about forty people, but also shares some personnel who are assigned primarily to other manufacturing activities of the company.

Molds are fabricated by M2 for the automotive, heavy truck, recreational vehicle and personal watercraft industries. Parts they make molds for include the outer body panels and inner, structural parts. In addition, molds are manufactured for other industries for parts such as plastic trash containers, furniture, and components of satellite dishes. About fifty percent of their business is automotive (including heavy truck).

The large, technologically advanced equipment in their shop enables M2 to build very large molds. This also raises their costs to a level which is high enough that their prices are typically not competitive when compared to shops that build smaller molds. Consequently, most of the molds they build are very large, and that is the segment of the market they concentrate on.

The bulk of M2's business is for the domestic heavy truck industry, and for the past several years has been dominated by SMC molds. M2's customers are molders who are typically first tier suppliers, and so marketing activities focus on keeping abreast of the activities of the dozen or so SMC molders that mold large parts. Most business is repeat business for current customers, although current plans are to resurrect the injection mold business and to pursue business in foreign markets.

Primary activities performed by M2 include the design and build of both molds and assembly equipment. Initial runs of the entire production and
assembly process are performed to verify proper operation before being shipped to the customer. Other services include providing process expertise, input to component designs, and extensive support to the molders.

Some molders get M2 involved in dialogue with the OEM to help define manufacturing requirements and provide process expertise early in a program. This type of service has been requested only on automotive programs, where fit and assembly issues are critical. Customers have been getting more and more design responsibility, and because they have no engineering staffs, or very limited engineering capabilities, M2 provides engineering services to these customers.

Outsourcing is often used when M2's shop is overloaded. Any services required in order to maintain the customer's delivery schedule will be purchased.

With respect to competition, M2 feels that they compete primarily against the minimum pricing philosophy of some customers who choose their mold source solely on the basis of price and delivery promises. Often, they will fail to see the value added in having both molds and assembly equipment provided by the same source. They also fail to evaluate the worth of additional services that the moldmaker can provide.

In the future, M2 would like to be known primarily as a supplier of complete production systems, and not just of molds.
CHAPTER 5

RESEARCH FINDINGS

5.1 Introduction

This chapter describes in detail the characteristics of the die and mold industry as reported by the respondents. For this purpose, the companies described in the last chapter have been divided into three market segments based on their primary products: molds, sheet metal stamping dies, and SMC molds. The products of the companies grouped together in a market segment possess similar characteristics, as described in the introduction to each section. The discussion focuses on the characteristics that dominate each market,\(^2\) and not on features that are unique to individual companies. Where distinctive traits are noted, they are identified as being unique.

5.2 The Mold Market

The companies included in this market include the manufacturers of die casting dies, injection molds and molds for glass containers. The die casting

\(^2\)Dominant themes and important factors will be identified with italicized text.
and injection molding processes share the characteristic that a molten material is injected, under pressure, into a cavity that is shaped identically to the outer surface of the finished part, with the exception of an appropriate shrinkage factor. If the part has been well designed for the process, it can be successfully cast or molded if the appropriate process parameters are chosen and the process is kept under control. Typically, the tooling manufacturer is responsible for verifying that accepted design guidelines have been followed in the component design, and then manufacturing a tool with the correct geometry. The parts producer, a caster or molder, is responsible for using their expertise to determine the parameters that are needed to produce parts.

The manufacture of glass bottles differs from die casting and injection molding in a relevant way. It is a two stage process. The first stage is used to create a preform shape that is inserted into the mold and then blown into the final shape. The process shares the characteristics that the raw material is in a fluid state and that the mold cavity has the geometry that will be present in the surface of the finished part.

In spite of the process differences, the manufacture of glass containers has more in common with injection molding and die casting than with the processes that have been grouped in separate markets. The differences will not

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10. Production tools for both these processes are often referred to as 'molds.' In the remainder of this section, 'mold' refers to production tools for all of the processes that have been grouped in this market.

11. There are, of course, exceptions, but these cases exceed the scope of this discussion.
affect the applicability of the market characteristics that are summarized in the sections that follow.

5.2.1 Description of Caster

The caster that provided the customer’s view for this study produces large, complex parts. Eighty percent of the company’s business is automotive, and the primary product of its largest plant is transmission cases. The company is best known for being able to successfully cast parts that are a challenge to manufacture.

Traditionally, this company has not been well integrated into the product development activities of their customers. They have, however, always performed extensive process analysis in order to evaluate manufacturability and design a robust casting process. Decisions regarding how a part will be cast are made in-house; and the engineers have traditionally taken an active role in die design, rather than relying heavily on die manufacturers to make those decisions.

The automotive customers are now demanding more design input from casters, which places a greater demand on the engineering staff. At the same time, die manufacturers have become more experienced at making highly complex dies, and are now given more responsibility for die design. This has been both a blessing and a curse, since competitors have been able to benefit by gaining expertise through the experience of the tooling supply base.
5.2.2 Customer Base

Mold manufacturers service a broad range of customers. The customer base includes both OEMs and first or lower tier suppliers. The position of customers in the manufacturing supply chain depends primarily on the structure of the industry.

For automotive work, the mold manufacturer’s customer is most often a first tier supplier to the automaker (see Figure 1). Some automakers still maintain a small number of casting plants, and some manufacturers of casting dies do direct automotive work (Figure 2). Outside the automotive industry, a number of manufacturers produce components for their own products, and the customer may be an independent caster or an OEM (Figures 1 and 2).

Manufacturers of plastic injection molds work almost exclusively for independent molders, and seldom have any interaction with the user of parts made with the tools they manufacture (Figure 1).

There are both molders and casters that have captive mold manufacturing facilities (Figure 3). In the available examples, these companies had a focus either on production or on mold manufacturing. Companies that have a production orientation do not have enough mold building capacity to meet all of their internal production needs (Figure 4). Those that have a mold manufacturing focus produce more molds for external customers than for in-house production needs (Figure 5).
Figure 1. Customer is an independent caster or molder

Figure 2. Customer is the OEM, molder or caster is captive to the OEM
Figure 3. Mold shop is captive, customer is the OEM

Figure 4. Mold shop is captive, firm has a production focus
5.2.3 International Competition

Of the firms included in this study, only one manufacturer of die casting dies spoke of offshore competition being a threat. In the die casting industry, the extent to which foreign competition affects a firm is highly dependent upon the customer base. Many of the smaller domestic manufacturers outside the automotive industry prefer to do business with U.S. based tooling suppliers. Foreign based manufacturers that operate assembly plants in the U.S. often choose domestic suppliers because of regulations on the percentage of domestic content. Automakers and high volume producers use both domestic and offshore sources.

Where foreign competition was a concern, the threat was not offshore die manufacturers. Rather, the erosion of the customer base due to casters moving offshore and to domestic manufacturers choosing offshore sources for their cast parts or moving their own manufacturing offshore were the primary threats:
"If I don't have any customers locally, or even in the near vicinity, then no matter how much technical expertise I have, if I've got to compete with someone that's a thousand miles away, or in Taiwan or somewhere like that, I'm dead. So, if my customers are not keeping up the die casters, then I've got a major problem." (R08)

The number of casters in that company's home region has decreased by an order of magnitude over the past decade.

5.2.4 Services

The services most widely provided in the mold manufacturing market are the design and fabrication of the molds. Component designs are usually inspected to verify that appropriate design guidelines were followed. If poorly designed features, such as insufficient corner radii or absence of draft, are present, the necessary changes are proposed to the customer.

Other services demanded will depend on who the customer is and what their capabilities are for performing the activity. For customers that do not maintain an engineering staff, the die manufacturer may provide that function and in that capacity will interact directly with their customer's customers.

For small manufacturing companies that have limited engineering capabilities, the mold manufacturer may design the part as well as the mold that will produce it. Large companies and automotive customers rarely demand this type of service.

Some injection mold manufacturers and larger die casting die manufacturers run parts on the molds before they are shipped to the
production facility. This service is not commonly provided by average and small sized mold shops. The expense of maintaining production equipment and hiring personnel that have the expertise to operate it cannot be justified by these companies unless there is a consistent and heavy demand for the service or they are able to utilize the machines with some production work. Die casting die manufacturers will sometimes run plastic parts in the dies to verify the part geometry and operation of the tooling.

Casters and molders feel that having the process proved out in the mold manufacturer's facility is often worth the additional investment because the molds can be "debugged" without taking production equipment offline. Any changes that are needed can be made before the dies reach the production facility, and they are provided with useful information regarding the process parameters that will be needed:

"...the molders don't like that either. Because they're cutting into their production, to sample something. And when you sample something maybe it takes an hour. Maybe it takes 10 hours. You don't know, and then you have other people saying "hey, I need that press to run production, when are you going to be done?" So, with us doing all of that in-house, they know when they get it in there, that they're not going to have problems with it. It's already been debugged." (R05)

"...in our industry, when you put a die in a machine, the time and energy that it takes to do that is unbelievably long and expensive. Some of those dies get anywhere from three to four thousand dollars a production hour. So, if it takes them eight or ten hours to change a die over, they're not making any castings while that's happening. If they fire that machine up and start making castings, but they're not any good and they gotta pull that die out. And then it's maybe
four, five hours to pull that die out and then another eight or ten to put a new one in. Send it back and have work done to it. The cost is unbelievable." (R19)

Die casting die manufacturers are aware of the increasing demand for this service and indicated that it may be a requirement in the future, especially for complex or difficult to cast parts. Captive mold manufacturers usually sample molds on production equipment before they are released for production.

5.2.5 Outsourcing

All of the companies included in this study outsource some work and some will occasionally accept work that is offloaded by other firms who need help when internal capacity is temporarily exceeded. The work outsourced by mold manufacturers is usually limited to specialty machining that they cannot perform in-house. Typically, the operations outsourced require a size or type of equipment that the mold manufacturer does not have in-house because limited demand makes it difficult to justify the expense. The mold manufacturers consider design and engineering to be core capabilities and keep those activities in-house.

5.2.6 Efficiency

Mold manufacturers attribute much of their efficiency and ability to manufacture molds for complex, highly detailed parts to their internal processes and equipment. Extensive CAD and CAM capabilities, operators that are able to monitor several machines, and machine tools that can run unattended, are all considered essential. State-of-the-art machine tools are
another tool that enables high precision work. The use of CAD and CAM have largely eliminated the need for many highly skilled die makers in the manufacture of molds.

"...the trade has completely changed since I started. And you really don’t make a lot of die makers anymore. You make a lot of specialty machinists." (R19)

In fact, the die casting die manufacturers refer to themselves as manufacturing companies whose primary products are dies and molds. Highly sculptured surfaces can be fabricated automatically on today's machine tools, and so all of the mold components can be designed up front. More time is spent on analysis and die design early in the program, reducing the need for several iterations of making changes while fitting parts together during assembly.

Additional improvements in efficiency are the result of experience. As the work force gains experience, they are able to process jobs more effectively. They learn what works and where time can be saved. Operators are often able to run several machines simultaneously. In addition, firms that get repeat orders, either on multiple mold programs or for replacement mold components, are able to increase efficiency on those jobs and pass the savings on to customers.

The sensitivity to price and lead times in the mold market are the primary driving forces for improving efficiency, and most deliberate efforts to reduce costs and improve delivery are the direct result of market pressures.
5.2.7 Selection of Mold Suppliers

Most casters and molders work with a relatively small supply base for their production tooling. Depending on the size of the company, they will use only a few sources to as many as twenty. The larger buyers may have a self-imposed limit on the amount of work they will source to any one mold supplier annually. Companies of any size may have a preferred supplier that they will always use when capacity is available there.

In this market more than any other, the sourcing decisions are dependent upon personal relationships between people in the die manufacturer’s and the buyer’s companies. It is common for them to be friends and to have social relationships, especially in the small and medium sized firms.

Competition in the market is also very sensitive to price. In spite of the influence that personal relationships have, the lowest priced source is usually chosen unless a higher price is justified because the job is technically demanding or a compressed delivery schedule is desired.

Strategic sourcing relationships are formed to provide a stable long term source for repeat items, such as die inserts on high volume production parts. All other jobs are competitively bid, even when there is a preferred supplier. The competitive bidding process may consist of several rounds in order to get the lowest price possible. For each round of bidding, a lower cost target is established, and the tooling manufacturers bid against the target. In the end, the supplier who is willing to accept the job for the lowest price will be
awarded the work. The preferred supplier may be given the opportunity to
match the low bid before the sourcing decision is made.

Die and mold buyers been heavily involved in the management and long
term strategy of their tooling suppliers. However, QS9000 registration is
expected of firms in the industry. so buyers know that a well documented
procedure of production has been established.

5.2.8 Product Development Practices in Customer Firms

Mold manufacturers very seldom have input into the design decisions for
products or components. Aside from minor changes that are required in order
to make the part manufacturable, they are not expected to influence the design
and product development decisions. The only exception observed was a case in
which the mold shop was a captive tool source. That organization is
sometimes responsible for the design of parts that they will be producing in-
house.

The process expertise in die casting and molding is the responsibility of the caster or
molder. The mold manufacturer provides a tool with the proper geometry, and
the molder or caster must determine the process parameters that will
manufacture a part with the required properties. Of course, mold
manufacturers that sample their molds in-house or are captive to a production
facility have a higher level of process expertise, and they feel that their
production experience helps them design better tooling.
5.2.9 Engineering Changes

Frequent engineering changes are characteristic of today's compressed product development cycles. Although changes are common and will almost always impact either the cost or the delivery of the completed tooling, they do not usually have a catastrophic effect on a mold program.

When engineering changes are minor, and are submitted early in the program, they are often incorporated without additional charge. Major changes that require a significant amount of rework are made for a minimal charge.

5.2.10 Benefits of Good Relationships with Customers

Good relationships with customers in the die casting die market are characterized by blanket agreements and strategic sourcing arrangements. These are not at all common, however, and exist primarily on products for which there is a repeated, long term demand, such as for replacement inserts and repair work.

The greatest advantage of a good history with a customer is the favorable rating they will give to the supplier, placing them in a good position to compete for future work. However, the role of past performance cannot be completely separated from having personal relationships with the people who make sourcing decisions in the customer's organization.
Customers that are interested in forming stable, long term relationships are more likely to give an appropriate lead time and benefit from lower costs just because programs do not have to be expedited.

5.2.11 Examples of Non-Traditional Relationships

Only one of the companies spoke of relationships with customers that were formally outside the bounds of what is traditionally observed in the industry. Two examples were discussed.

With one customer, the die manufacturer had a blanket agreement to provide a particular die insert over a number of years. The agreement, essentially, was to provide the part, on demand, for the same price originally agreed upon. The customer simply issues an order when the parts are needed. The savings realized by the gains in efficiency are passed on to the customer.

In another case, the customer has a commitment to the long term success of the die supplier. A competitive bidding process is not used. The two companies work together to determine fair prices. Orders for repeat work are issued without renegotiation:

"...they already have proven that once you do a job and they're happy with your price, they don't requote you. They just send you the work. ...We've dealt with the same purchasing guy ever since we've done work with them. They definitely are concerned about you being around to help them. Especially if you're just doing what you're supposed to do. And that's deliver quality. On time. Then they want you around to service them.

"Where I think a lot of other companies look at people as dime a dozen. For instance, we're doing jobs out there that the same job has
been being built for years. They know exactly what that piece is worth. If they had theirs and your best interest in mind, they’d come to you and say, "here’s a tip you can build. It’s twenty thousand dollars. You’ve got a three year blanket." No problem. Actually, that’s what (this customer) does. (The customer) brings work in here. ...you develop a price and you go on it.” (R19)

The benefits are realized by eliminating the costs associated with the competitive bidding and quoting processes. In addition, a liaison based on mutual trust develops and is strengthened over the long term.

5.3 The Sheet Metal Stamping Die Market

The manufacturers in this market segment make dies for sheet metal stamping. Sheet metal stamping is a multiple stage process in which several dies form a part from a blank in a series of sequential operations. Success in this process is dependent upon an understanding of the flow of material in each operation. The die manufacturer is relied upon to provide this knowledge.

5.3.1 Customer Base

Manufacturers of sheet metal stamping dies have more interaction with OEMs than die manufacturers in any other market segment included in this study. This is primarily due to the fact that in the domestic automotive industry, manufacturers are more likely to produce auto body components in-house than other near net shape parts. Even so, their internal capacity is not sufficient to meet all of their production needs, and body panels and other stamped parts are also procured from independent suppliers. Consequently,
the customers of the stamping die manufacturers are both automotive companies and stamping plants that are first tier suppliers to them (see Figures 6 and 7, respectively).
Another attribute that is unique to the stamping die segment of the market is the fact that all of the automotive companies maintain their own stamping die manufacturing facilities. Again, their internal capacity is inadequate to meet all of their production needs. Some first tier suppliers of stamped automotive body panels have captive die shops as well, but they are the exception rather than the rule. The company included in this study that produces stamping dies only for black metal parts is captive to a first tier supplier.

When the customer is a first tier stamper, there is usually no interaction between the die manufacturer and OEM. However, when the customer is the OEM, it is likely that the stamping die manufacturer will interact with a number of functional groups within the customer's organization, as shown in Figure 8.

**Figure 8.** Interaction of stamping die manufacturers with their customers
5.3.2 International Competition

Competition for the business of foreign customers and competition from offshore tooling sources have both impacted the stamping die market. For many domestic die manufacturers, the competition from foreign tooling sources for the domestic business has had a greater impact.

Most of the business of the Big Three is sourced domestically. Even the first tier stampers source the bulk of their dies domestically. The competition from foreign tooling sources becomes an issue primarily when there is little business in their home markets. Die manufacturers believe that the social programs in the home countries of their offshore competitors allow those companies to set prices for their tools well below their actual costs. Prices may even be close to the material costs. These aggressive pricing strategies sometimes allow foreign competitors to gain a share of the domestic stamping die market. Savings that can exceed thirty percent on the total cost of a tooling program occasionally entice even loyal customers to source work abroad. When work becomes available in their home markets and government subsidies are not available, foreign competitors are not as attractive to the domestic automotive stamping die market.

Few domestic stamping die manufacturers actively compete for work abroad on a regular basis, although several work for the domestic plants of foreign companies. It is difficult to compete directly for foreign business.
because the industry norms abroad differ significantly from the domestic market.

Tooling programs for domestic customers are usually of the full service type, and the pricing of domestic die manufacturers reflects that. Foreign customers, however, often perform all of their die tryout in the production facilities, so the tooling prices in their home markets is much lower. The extent to which the skill base of die manufacturers is valued is therefore much lower; while the value that this skill offers to the market domestically is one of the die manufacturers' greatest assets. Some of the greatest challenges of marketing services abroad are selling foreign customers on the superiority of the services offered, and encouraging them to find a common basis for comparing the overall value of that service.

5.3.3 Services

Stamping die manufacturers offer a range of the services associated with process development, die design and fabrication, and tryout of the dies. The services offered by companies included in this study were discussed in the individual company descriptions in Chapter 4, and are representative of the industry. Typically, stamping die manufacturers that are primarily first tier suppliers in the automotive industry consider themselves full service
suppliers. This section will focus on the services demanded by the customer base rather than on those capabilities maintained by the die manufacturers.

The services desired by customers encompass a range of activities. One automotive manufacturer often performs all of the prototyping and die development activities in-house and designs all of the dies in the line-up. They will then order the castings and have them delivered to the die manufacturer that has been selected to build the dies. No input from the die manufacturer regarding the appropriateness of the design or the process is either solicited or welcome. The die manufacturer may or may not then be responsible for tryout. They may be asked only to get the dies to the functional stage, and then deliver them to the customer, who will complete the tryout activities within their own die shops. Not surprisingly, this automaker’s internal die tryout capacity is often exceeded, and they contract die manufacturers to perform tryout on dies that may have been built elsewhere.

So, requested activities range from die build only, or die tryout only, to full service. A full service program will include prototyping and process

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12'Full Service Supplier' is a formal term used by one of the domestic automakers and has strict guidelines regarding the capabilities a supplier must maintain in order to qualify for the rating. However, the term 'full service supplier' is also used less formally by some of the die manufacturers to indicate their ability to take full responsibility for an entire die build program. The die manufacturer will either perform or acquire from their customer base all of the activities and services that their customer demands as part of the program. Here, the phrase is used in its less formal sense.

13Most die manufacturers do not maintain the capabilities to meet all of their customer’s demands in-house.
development, draw die development, die design, fabrication of all die components, die construction, bench work, and tryout. Some die manufacturers will market each of these activities separately as services, but typically only as second or lower tier suppliers.

Outside of the die build and tryout activities, the services demanded by the customer organization will depend primarily on the level of expertise maintained within the customer's product development groups to perform or supervise those activities.

One additional service that is demanded of die manufacturers is on-site support during tryout in the home plant. Die manufacturers feel they can help to solve any initial problems and can prevent premature modification of the tooling when they are present.

"We have a video library of all our dies. On a die, you have a binder, you have, what you call a draw bead. Okay. Lot of times you've got your draw beads working good here, and it's making a good part, no wrinkles. Well, you get into a stamping plant, and they might have a little problem. First thing a die maker does is blow a bead off. Well, then the thing is kind of screwed up, they call and, 'hey, you guys sent us a piece of junk.' 'Wait a minute, that wasn't like that when it left our plant. Here's the proof. If we were here to help you, we could have helped you do it...’" (R13)

The die manufacturer's presence is not permitted in some stamping plants because of union regulations.

5.3.4 Outsourcing

All of the companies in this study outsource work to provide additional capacity when their internal capacity is exceeded. The extent to which
companies plan to use capacity in other shops varies widely and is dependent upon several factors.

The desired business volume is one factor affecting the volume of work outsourced. Some companies try to maximize the number of programs they win with little regard to their internal capacity. They plan to manage other shops and use the outside capacity to meet their commitments. This happens by default in captive shops. In those organizations, programs are sold based on production capacity, and not on the die build capacity. If the internal die build capacity is not adequate to meet the needs of the production facilities, then complete dies or die components must be outsourced.

A more common strategy used by independent shops is to sell programs that will fill internal capacity. Work is then outsourced only when conditions temporarily cause internal capacity to be exceeded. These conditions usually have to do with the timing constraints of large programs. Either there is some overlap of programs that necessitates additional capacity in order to keep all of the programs on schedule, or the scope of work in a program changes drastically enough that the original schedule cannot be maintained without additional capacity.

The types of work outsourced also depend on the company's strategy. Those companies that see their strengths in certain areas, such as their engineering capabilities or their skill in tryout, will keep these activities in-house.
The types of activities outsourced may also change over time. For example, two companies that had previously kept all of their design work in-house will now outsource a portion of that work. However, all of the design work done in solids is performed in-house. Both of these companies see solids-based design and manufacturing as an eventual standard in the industry, and are focusing their engineering efforts on developing and maintaining those capabilities, while allowing external vendors to handle other design activities.

Activities that are considered cyclical and that require a set of skills not deemed critical to long term viability may also be outsourced. For stamping die manufacturers, these would include activities such as prototyping and soft tool development, as well as finite element analysis. The larger the company, the more likely it is that they will have a business volume large enough to support these types of activities in-house. In fact, the smallest of the companies included in this study performs only die assembly and tryout exclusively in-house. At that firm, many other fabrication activities are regularly outsourced, and all support activities such as prototyping, design, and analysis, are outsourced.

Companies that considered design and engineering activities core capabilities were more likely to be first tier suppliers, while those that operate primarily as die build shops had a larger portion of customers in the first tier. In addition, companies that considered themselves a job shop and would even
consider acting as a subcontractor for other die shops and manufacturers were less likely to have their customer base dominated by OEMs.

As might be expected, companies that outsource work only to provide excess capacity in peak periods are more likely to have a small number of 'strategic build partners' that they have a proven history with. In the long run, they may be responsible for a significant portion of those shops' capacities, upwards of twenty or thirty percent. The proven history of consistently providing a significant volume of strategically selected types of work allows these relationships to continue in an atmosphere of trust and eliminates the need for continued close supervision. This is in contrast to the companies that outsource large percentages of their work on large programs to many outside shops that they have varying relationships with. These companies need to have a larger staff of program managers just so that they can monitor, manage, and supervise the work that has been outsourced.

Although die manufacturers claim that customers frown upon extensive outsourcing, they will justify it when they want to do it and take measures to show the customer that the work is being well managed.

5.3.5 Specialization

Many stamping die manufacturers have an area of specialization. Although they may produce dies for parts outside of their specialty, their marketing efforts are focused; and they readily admit that their core capabilities lie in one or two key areas. Some areas of specialization include body side
apertures and the mating parts, doors, trunks and hoods, roofs, quarterpanels, fenders, beds for pickup trucks, floors, oil pans, and drive train components.

The focus of specialization on dies for certain types of parts allows the companies to become more efficient and knowledgeable in that area. This gives an advantage to the buyer when choosing tooling suppliers. Companies that do not have an area of focus were more likely to have customers that are first tier suppliers rather than the automotive companies themselves. They are also less likely to have a very stable and consistent customer base or to be presourced as a preferred supplier.

5.3.6 Improvements in Efficiency

Many of the factors that allow die manufacturers to produce dies more quickly and at lower cost are due to technological advances in the processes used in die manufacturing. The time required for die build activities has been shortened significantly, while more time is now spent up front in die design and engineering activities. The complete design of dies in a CAD environment, and the fabrication of die components using CAM has made the die manufacturing process more like other job shop manufacturing.

The skill in the manufacture of stamping dies is concentrated in the assembly and tryout activities. High speed machining and automated polishing have enabled the elimination of handwork on some dies, and reduced the handwork required on dies for Class A finish panels by eighty to ninety percent.
Over the last fifteen years, the lead time on large programs has been reduced from close to two years to just over one year. This large decrease in the amount of time required to manufacture dies accounts for savings in the cost of die makers in the program. The overall program costs, however, are not lower. The investment in advanced machinery, computer hardware and software, and engineering staff has merely shifted the proportion of costs allocated to different activities.

Even with the current, improved methods of manufacturing dies, some die manufacturers make a conscientious effort to systematically reduce the time spent on the most costly and time consuming activities, typically those that require hands-on work by highly skilled die makers. These efforts have been responsible for recent reductions in lead times and costs.

Although such efforts continue, die manufacturers believe that great improvements in both lead times and costs of die programs can be achieved only when customers change their requirements for die qualification so that they are more functionally based. The die manufacturers spoke of scenarios in which requirements added time and cost to a program, but had no bearing on the function or appearance of a part. One such example follows:

"...classic case is that you have an inner panel and an outer panel. All right? The outer panel, the customer has a tolerance requirement on it. Sometimes both in a clamped state and in a free state check. Well, as soon as you take that outer and you hem it to the inner, what’s the outer going to do? It’s going to adhere to the inner, because the inner’s got all the structure. The outer’s just, we call it
wet noodles. Cause sometimes they’re just so flimsy. So, they’ll make us fight that outer to get a nominal detailed stamping. And then, as soon as we hem it to the inner, it’s no longer a detailed stamping, it’s an assembly. So, all that work, in many cases, absolutely doesn’t mean anything. It’s almost meaningless. But they’ll make us do it. And then, what they do, they say, ‘okay, now we’ve got this hemmed assembly. And it’s out of tolerance.’ So, now what you’ve got to do, you’ve got to go and exaggerate this (part). So, when you hem it, it comes back. So, we fight these details. And as soon as we put them together, even though the details are right, the hem isn’t right. So, then you have to go and modify the hem die. modify this detail, modify this detail, so that they come back together. And, there’s two intermediary steps in there that, many times, add no value. We’ve tried to tell the customer umteen times. A lot of them recognize it, but their process doesn’t allow it. They buy by the numbers. And this panel, before they’ll buy it, has to fit their numbers. Same with this one. And then, they don’t care. Even though we stick them together, this is another step. Somebody else pays for that one.” (R01)

Evidently, the designers and quality specialists that provide specifications for the purchased parts don’t take a broad view of the purpose of the components. Even when suppliers propose changes that will improve their process, they are unwilling to consider change. Again, their behavior provides evidence that product development activities are not well integrated.

Die manufacturers do not feel that customer’s demands are directly responsible for the steps taken to improve efficiency in their manufacturing processes. There is an implicit demand for greater efficiency due to the pressures for low costs and the increase in the volume of engineering changes without an increase in the lead time. The shops that are attentive to efficiency take the initiative to make improvements in their processes. The benefits
realized from these improvements are then used to gain a competitive advantage when contending for new business.

5.3.7 Selection of Stamping Die Suppliers

A number of criteria are used in the selection of a stamping die manufacturer.\(^4\) The most obvious of these is the ability of the supplier firm to perform the desired work, and to deliver the program at the desired time.

In addition, the die manufacturer must be willing to work for the buyer. Some die manufacturers that have the ability to compete as first tier suppliers for automotive programs will not work for the automotive companies.\(^5\) These companies prefer to work for other die shops or for first tier suppliers.

Die manufacturers claim that price is not the most important factor used in selecting a die supplier. Still, most die programs are competitively bid.\(^6\) A number of different scenarios may arise during this process, depending not only on what the formal sourcing strategies are within the customer's company, but also on the personal preferences of the procurement people and product development staff of the particular car platform.

\(^4\)These criteria are as reported by the die manufacturers.

\(^5\)None of the respondents in this study belonged to firms that expressed this preference. None were certain of the reasons firms have for not doing business with the automakers. Some of their suppositions were that these companies had an inability to manage the Big 3 as customers or did not want to manage the range of services expected by these customers.

\(^6\)When the die manufacturer is presourced as a preferred supplier, they may not be required to competitively bid for the program.
Even for die manufacturers captive to a first tier supplier, pricing is an important factor. Tooling costs that the buyer feels are too high may affect the company’s ability to win the production program. That, coupled with the fact that the die group is typically expected to be profitable as an independent cost center, forces them to remain competitive.

Die manufacturers captive to the automotive companies are not generally considered competitive when it comes to costs. They acquire enough work to fill their shops primarily because union agreements require that the automakers keep a certain level of work in their own die build facilities.

Quality is not mentioned as an important factor because, they say, “quality is assumed.” This makes quality a qualifier for competing in the industry, and not a means of winning orders. QS9000 registration has also become an industry qualifier. Most firms are either QS9000 registered, or are currently completing the certification process.

5.3.8 Contact Between Die Manufacturers and Their Customers

Die manufacturers often maintain close contact with customers during a die build program. The lead times on automotive stamping dies are approximately one year. During that time, teams of personnel from both organizations meet regularly, either monthly or bimonthly, to resolve open issues and monitor the progress of the program. These meetings are often hosted at the die manufacturer’s organization so that customers can visit the shop floor to check the progress of their tools.
Additional communications initiated by the customers are typically for the purpose of making changes to the design or to further compress the delivery schedule.

Stamping die manufacturers often have a significant amount of interaction with their customers even before the die programs are officially launched. When early sourcing decisions are made, representatives from the die manufacturer's organization may be involved in meetings at the customer's facility where styling decisions are made, even twelve to eighteen months before designs are released for tool build.

Die manufacturers often find it beneficial to develop a relationship with upper levels of management within the customer's organization. When they are not getting information in a timely manner or are not getting the "right answers" from people within the customer's organization, things can often be expedited by involving higher levels of management and communicating the impact that delays or uncooperative attitudes are having on the program (refer to Figure 8).

Problems are also elevated to higher levels of management when a strategic die source refuses work that they have been sourced because the price targets that have been set for the program are too low. The approval of upper management may be required to authorize the higher price which has been justified by the supplier.
Visibility at high levels of management also results when die manufacturers issue a refund on the cost of a program because of savings realized because of improved efficiency.

5.3.9 Product Development Practices in Customer Firms

Domestic automotive companies are becoming increasingly reliant upon their suppliers during new product development. Typically, this has a greater effect on parts suppliers than on tooling manufacturers. However, in the stamping die market, die manufacturers provide much of the process expertise that is incorporated into early design decisions.

Stamping die manufacturers are often consulted very early in a new product introduction, as soon as styling decisions have been made. Their role at this stage is to assess the feasibility of manufacturing the proposed designs. They inspect the proposed panels and provide feedback regarding the difficulties that will be introduced during manufacturing due to specific features in the designs. The process expertise in sheet metal stamping usually rests in the die manufacturer and not in the parts producer. In fact, the stamping plants consult die manufacturers and die makers for assistance in improving the process. Die manufacturers also propose changes to the process or the product that will result in savings not only on the tooling costs, but also on production costs.

Manufacturers have traditionally relied upon the expertise of designers on their product development teams to provide this type of input. However, with
the higher attrition rates in their engineering staffs due to promotions and
downsizing, the product development teams are often dominated by young and
inexperienced engineers. The supply base, which typically has a more stable
work force, is needed to bring experience and to remind the design teams of
lessons learned in previous programs.

Because suppliers interact with a number of people in the customer's
organization, they regularly experience the effects of conflicts within the
customer's company. Delays in making decisions result from a lack of
understanding or agreement between the styling and manufacturing or
assembly functions. When these groups do reach agreement, and the decision
results in an engineering change, there may be a conflict regarding which group
is responsible for paying for the change.

Despite the inexperience that often characterizes the product
development teams, the product introduction schedules have become very
aggressive. Add to this the lack of interaction between different functional
groups in the manufacturer's organization, and the result is designs that are often
incomplete and unstable when released to suppliers. A greater number of engineering
changes, later in the program, has become the norm. New product
introductions have been shortened, and stamping die suppliers feel that the
aggressiveness in product development far outweighs the performance of the
design teams.
5.3.10 Engineering Changes

Because of the compressed lead times and instability in designs when they are released to die manufacturers, *engineering changes occur more frequently, and later in the programs*, than they have in the past. The change in the scope of work due to engineering changes during a die build may exceed one hundred percent, more than doubling the overall cost of the program. Most changes can be incorporated into the existing, incomplete tools. Occasionally, however, changes are drastic enough that it is necessary to scrap the work in progress, develop a new process, redesign the entire die set, and start die manufacture from the beginning.

Most engineering changes are made without an accompanying change in the delivery date. Completion of the program within the original schedule then requires that overtime hours (at premium prices) be used to complete the work. Automakers are almost always willing to pay a premium in order to keep a program on schedule, and the pricing for incorporating engineering changes is the only activity which contains a healthy profit. Hourly rates for engineering changes may be as much as three times the standard rate.

Depending upon the scope of the change, the program delivery date may be unavoidably delayed by anywhere from a couple of weeks to as much as a year. When engineering changes cannot be incorporated without impacting the due date, additional approvals are needed from the customer. It is not
unusual for the customer to abandon a requested change in order to maintain the original production schedule.

The cost of incorporating changes is a greater factor for customers that are first tier suppliers. Although they demand the change and will approve it in order to expedite the program, they are often not willing to accept the die manufacturer's pricing and will come back to negotiate prices for engineering changes even after program completion.

Engineering changes initiated by the customer are usually motivated by one of two factors. Either the component has a significance where safety is concerned, and the change must be incorporated in order to meet federal crash worthiness standards, or there is an integration problem, and the part must be changed in order to properly interact with adjacent parts or eliminate interference between parts.

The necessity for many engineering changes can be traced to poor design decisions made by inexperienced design teams or to miscommunication between different organizations or functional groups that are responsible for product design.

Changes proposed by the die manufacturer or part supplier are motivated either by improving or enabling manufacturability, improving the efficiency of the assembly process, or reducing production costs.
5.3.11 Design Changes Initiated by the Die Manufacturer

Despite the fact that the expertise of die manufacturers is solicited during the product development process, product development teams are often reluctant to incorporate their suggestions. The number of obstacles in having design changes accepted is dependent on the historical relationship between the die manufacturer and their customer, the nature of the change, and the time during the program when the suggestions are proposed.

One reason that die manufacturers like to get involved in a program very early on is that they have more of an opportunity to influence design decisions. After the program has progressed and data has been released that is dependent on the current design, the design teams are reluctant to make changes without a significant amount of justification.

Although the customer's organization may have a great deal of confidence in the die manufacturer, "the customer" is many people. The design team may choose to maintain more of an antagonistic stance and be defensive of their design decisions. They will then make it very difficult for any outside party to have any influence on their designs and will consider their recommendations only if there is great pressure from their superiors.

Suggestions for changes must be accompanied by evidence that the change is justified. Changes for feasibility or manufacturability reasons sometimes need to be proven by analysis or demonstrated in the soft tool stage before they will be incorporated. Other changes are considered only if it can
be shown that they will result in a substantial savings, either in the tooling costs, or in the production or assembly of parts.

5.3.12 Benefits of Good Relationships with Customers

Good relationships with customers in the stamping die market are characterized by trust, open sharing, and more opportunities to influence the customer's processes. The die manufacturer's role then extends beyond just a die build source, to a strategic partner in product and process development.

Die manufacturers that gain this status are presourced for work with the OEMs or given formal status as a preferred or strategic die source with their first tier customers. They are then able to get more information about the process, and can address potential problems before they become obstacles:

"...you've got people on the other side (whose) jobs are dependent on your performance, and if you can continually keep your customer involved in what you're doing, and where you're at, and know what you're doing, then you can keep them and you, as much as you can, out of trouble. So, we both can try to perform. In general, the customers that allow us the opportunity to do that, most of the time, we are involved much earlier, up front. So we are much more knowledgeable about the process. How the process was created. The difficulties that were involved in the creation... when you start with a new vehicle, a lot of times, the process by which you're going to make each detail in that. Somebody has to figure it out. And sometimes it's not always done the best way. And if you're involved in that up front, you can be more proactive to whether or not there's a problem. Or if there is a problem, how you can fix it, earlier on, because you have the chance to become involved. The more of a purely die build shop that we become, the less we can help the customer. The more we can promote (our company) as a service company... Even though our primary product is something that we fundamentally build, we still view what we do as being a service. (R01)"
The primary benefit to the die manufacturer is the ability to know what their commitments are for 24 to 30 months into the future. This enables them to make staffing and investment decisions and to reserve capacity in their own supplier base. Knowing far in advance what work is coming is invaluable to die manufacturers, and they strive to build relationships that give them that opportunity.

Die manufacturers that have a good relationship with their customers feel that they share in the problems that arise during a program, and not that the customer dictates to them or expects them to take full responsibility for problems.

Personal relationships with staff in the customer's organization gives die manufacturers an opportunity to get more information about their status during the competitive bidding process. They have the opportunity to negotiate and may be better able to position themselves to obtain the business.

5.3.13 Relationships with Other Die Manufacturers

Stamping die manufacturers typically develop relationships only with other companies in the industry that either they contract or they are contracted by to provide excess capacity. For the most part, the organizations exist in an atmosphere of friendly competition.

Closer relationships between organizations often materialize because of relationships that were formed in the past. Because of the relatively small number of firms in the industry, most people know each other, and former
customers may become administrators in competitor firms. Most of the information sharing between competing companies has a foundation in these types of relationships and consists of the sharing of strategies regarding process or internal management of operations that will improve efficiency.

Sharing work on a large program or technical information was observed only when one of the die shops was captive to a customer's organization. In these instances, the shop was not considered a competitor, so the sharing of such information was viewed merely as servicing the customer.

Competing independent die manufacturers are not asked to collaborate on large programs. Even in a case in which competing firms had different portions of the same program and were aware of problems that needed to be solved in order to successfully complete the program, all of the decision making was done by the customer. Two very capable firms were not allowed to collaborate to solve the problem and present the proposed solution to the customer. In that case, the customer's failure to address the issue in a timely manner impacted the schedules of both die manufacturers.

Only one case was observed in which competing die manufacturers were asked to collaborate to share technical expertise in order to solve a customer's problem. In this case, the customer's firm asked the two die manufacturers to solve problems that materialized in heat treating a die material that had been specified by the customer.
5.3.14 Examples of Non-Traditional Relationships

Manufacturers of sheet metal stamping dies shared several examples of customer relationships that have evolved beyond the traditional competitively bid die build programs. A few of these relationships will be discussed in order to show how die manufacturers in the market segment have become involved with early sourcing and product development activities. The respondent’s comments convey their views regarding the impact these evolving relationships are having on their businesses.

Case 1. In this case, the die manufacturer was preselected by a first tier automotive stamper. As part of the program, the die manufacturer was invited to the automaker’s facility for a product review. The die manufacturers were depended upon to provide expertise in evaluating the designs for feasibility and designing the process.

"...we were going to be their source to build the tooling. And we were also going to be their experts in that area inasmuch as they were primarily stampers. Didn’t know anything about tooling. They knew how to put it into a press and make thousands and thousands of parts. But didn’t know anything about tooling maintenance...

"At one point we were invited to (the automaker’s) complex for a product review to see if there were any feasibility issues in making that part. And if we felt there were any issues, it was our opportunity to speak up... At that meeting they said if it was styling, too bad. If it was feasibility, that’s another issue. And, what we actually saw was the vehicle mock-up out of wooden patterns. And we had an opportunity, and we did make some minor changes. Nothing drastic. ...we pointed out some concerns. ...if we couldn’t address it in teamwork, then we would go back to that modeling stage, look at a feasibility study to perhaps change that. Get the
stylists back in. But there were some suggestions that were incorporated to make it a little better process. From a feasibility standpoint.” (R04)

This was one of only two cases in which stamping die manufacturers told of relationships in which they had a non-traditional involvement with first tier stampers. In the other case, the die manufacturer had an agreement to be a strategic tooling source for the stamper. Because that relationship was new, the long term advantages it may afford are as yet unrealized.

Case 2. In this case, the die manufacturer has what they describe as a partnership with their primary customer.

“The relationship is a partnership. And they consider the same thing. We are a team. And we are asked to join that team. We are a part of their staff. And the big difference is, is that’s what I see from the way is was to the way it is now. Is we are a part of their staff, and we are considered their staff. As a vendor. (We have) frequent contact, we attend their internal management meetings. They’re open. They have the trust, the respect, to accept us to join them as a partnership team. I don’t know if it’s ever been there like it has now. I don’t think it has. I think it was more of a, “that’s a vendor. We’re the customer. We tell the vendor what we want. I don’t want to hear anything out of that vendor. We’re gonna tell them what way they’re going to do it.” That’s the wrong way to do business. ...We’ve been accepted by (the customer). I mean, I see that. I see that as the major difference.” (R16)

Two factors that have been key in advancing this relationship have been the opportunity to provide design input, and relationships with higher levels of management. Both of these have led to fewer problems in designs:

“Generally what trips us up, is in an early kickoff to a vendor, without the product being stable. And the miscommunication between body and assembly. Or the assembly people and the
stamping people from a feasibility standpoint and manufacturability standpoint. What can be done as a stamping, and what can be done as an assembly. That communication, nine times out of ten, fails. Somewhat. When I say fail, I don't mean a complete failure. I mean it's not perfect. That's notoriously always a problem. In the manufacturing industry, you'll probably hear that a manufacturing engineer, and a product engineer never get along. Never, ever get along. And the reason why is because this so-called saving out there that a product engineer will always somehow, some way, design a part that can't be made. That cannot be manufactured. And that's why we sell this, we offer and sell a full service philosophy. That we can get started up front as a supplier to a customer, we want to be able to be part of that feasibility. Design input. That's the key. That is the key to success on a program." (R16)

"And management now sees that people have made decisions that cause a program to fail, or disrupts a program. They, management, can see that. I think the greatest influence is that when (the customer) changed management, that management had a more technical background and understood the issues that we were trying to address. And I think that our involvement prior to that was not to management but under management. And our involvement now is with higher management that have the expertise, that have been in the trade, that understand where we're coming from, and accept it. I think the way it was set up before was, more of the technical issues were dealt with mid-management technical people. And when we dealt with upper management before, it was like you have a catastrophe. You have a problem. It was always a major issue. Now we work with upper management and these major issues are not a major issue. Normally. They get discussed and resolved before they become a show stopper." (R16)

The added involvement in design leads to savings of both time and money:

"Well, the savings comes in when we're able to help assist (the customer) on formability of a part from a technical standpoint. If we can actually make the part. Or we'll go in and we'll tell them, based on surrogate panels, you had surface problems in these areas. You need to soften up a radius or you need to soften up a corner in a panel, or something like that. We help them actually design the product. What it does is, that saves time because if we don't get involved up
The customer makes sourcing decisions six to eight months earlier than in the past: the die manufacturer has committed hours through the next 30 months. When the die manufacturer is the preferred tooling source, jobs are not bid in an open competition. Rather, bids are against the customer’s internal cost targets only.

*Case 3.* In this case, the die manufacturer is a preferred source for a certain type of die. Basically, they know that for their customer, they will typically be the source for those parts.

"Now we’re a commodity source for their (specifc family of parts). So, any vehicle that they have coming up, there’s a (part of that type), and other parts mating to it, I automatically know that. So, say for the years 2001 and 2002, I know I’m gonna be getting the (vehicle model 1). I’m going to be getting the (vehicle model 2) program. I know that the first panels won’t be due until December 6, 1999. So, I know now, my future, what I’m gonna to be working on.

"The five or six key suppliers that (the customer) has. They’re all pretty much commodity sources. Like (die shop 1) will get doors. Okay? Cause that’s what their expertise is. (Die shop 2) is an aperture. (Die shop 3) may be a fender or quarterpanel. ...and they try to keep us (doing the same things), so (we) can become very efficient at those types of dies." (R13)

The security that this understanding affords does, however, come at a price:
"They do not competitively bid. But they have a target number that they want us to come in at. ...Supposedly their estimating goes through. New model estimating goes through and puts a number on it. (This customer) is the worst one. They are the lowest priced of any of ‘em. ...I do believe they’re unreasonable compared to the other companies.” (R13)

In spite of the lower prices, the relationship is valued. The opportunity to get involved with feasibility issues early on may actually result in higher profits.

“(early involvement) is actually a help to (the customer). But it’s also a big help to us. Cause we’re getting an earlier look. We’re avoiding a lot of problems that we normally have. ...In later activities, I see it as decreasing (our costs). And I don’t see it increasing up-front costs at all. We’re able to actually lessen our costs to our customer, and internally lessen our costs. (It improves our profit) I’m going to probably say, at the most between ten, fifteen percent. And that’s just a guess.” (R13)

Case 4. In this instance, like the previous case, the die manufacturer is a preferred source for dies for a certain family of parts. As in the previous case, work is sourced well in advance.

“I can tell you right, right now, in terms of timing. We’ve been preliminarily, preliminarily sourced 2002 work. And this is ‘97. And, but we’re looking at 2002 work. Back up right here, just so you don’t think this is really, 2002 launch. If the vehicle is a 2002 vehicle, typically it will launch in 2001. Typically in the fall of 2001. So then you can back up from there till today, and they’re already doing their sourcing. Not so much processing, but they’re doing their sourcing. Who’s going to do what.” (R01)

In spite of the history that the two companies have, the commitments are still rather informal.

“It’s actually even a little more casual than that. They’ll come and say, “on the 2002 vehicle we want you to build all the doors.” Simple as that. No more complicated. No more sophisticated. And
then we commit to the hours. So, right now we're committed almost through the end of '99. Right now. Mainly because of presourcing. So, we're committed the rest of this year, all of next year, and almost all of the year after that. It's incredible. I mean, for us it's incredible that we can know we have work that far ahead. But what it does, it allows us to plan. We set aside work, we can facilitate for it. Not just from a human resource standpoint, but from a capital standpoint. You can be so much better prepared for the workload when it gets here if you have some idea that it's actually coming.”

(R01)

In spite of the planning advantages this early sourcing provides, there is a risk to the die manufacturer. Problems can occur when either the work does not materialize because a program is canceled. Then the die manufacturer simply has to go to the market and find other sources of work. In general, the die manufacturer feels that the benefits of this relationship far outweigh the accompanying risks.

5.4 SMC Compression Mold Market

Companies included in this market segment manufacture SMC molds. The SMC molding process is a one step operation in which a mat of fiberglass reinforced polymer is compressed between the two halves of a heated mold. The material melts and flows to fill the mold cavity. After being given time to cure, the part is removed from the press.

SMC molding is similar to other molding processes in that the geometry of the finished part is identical to that of the mold cavity, and it is a one step process. It differs, however, in that it does not have a molten material injected into the mold cavity under pressure. From a manufacturing standpoint, SMC
molds share a great deal in common with sheet metal stamping dies. Because SMC molding differs significantly from both other molding processes and sheet metal stamping, it has been categorized as a separate market. The expertise applied to manufacture good quality molded parts is provided by the molder.

5.4.1 Customer Base

SMC molders are usually first tier suppliers to the OEM (see Figure 9). The primary product line is automotive body panels, for heavy trucks and passenger cars. There are other products, but most of the discussion with SMC mold manufacturers focused on automotive customers and products.

Both the SMC market and the SMC mold market are dominated by only a few companies in the U.S. There are about eight SMC mold manufacturers that compete for business from approximately a dozen customers. The molders in this industry do not have internal mold shops.

![Figure 9. Customer Base of SMC Mold Manufacturers](image-url)
5.4.2 Services

Manufacturers of SMC molds typically only design and build production tooling. The demand for other services is dependent upon the experience of the design engineering staff in the customer's organization. Some molders do a very good job of designing components for the process. Others, because of shrinking design staff and the inability to handle electronic data from their customers, request assistance from the mold manufacturer in design activities. When engineering input is required the additional services provided by the mold manufacturer may include designing components for manufacturability, resolving fit and trim issues, and planning for the assembly of the components.\(^{17}\)

Tryout of the molds is performed in the mold manufacturer's facility. If the mold manufacturer is also supplying assembly equipment, the entire production line is run-in house.

5.4.3 Outsourcing

SMC mold manufacturers outsource work when internal capacity is exceeded. For most, external sources are used to provide additional capacity temporarily. However, some regularly use external sources to provide many of the support functions such as design of the mold and much of the fabrication of the mold components, keeping only the mold construction and finishing

\(^{17}\)The mold manufacturer that offers these services manufactures assembly equipment within their company.
activities in house. Although customers do not favor that approach, they do accept it if the outside sourcing does not cause quality to suffer or lead to delays in delivery.

5.4.4 Selection of SMC Mold Suppliers

Suppliers of SMC molds are chosen using price as the primary criterion. Even though molders may have personal relationships with a preferred mold source, they may opt not to source work there if they can get a lower price from another source.

The advantage that preferred suppliers have is that the molder may give them a second opportunity to meet the lower price that was obtained during the quoting process. According to one respondent, delivery is the most important factor in supplier selection, but price is always critical:

"I tell you if I build a mold on time, that carries a long (way). Delivery on time, to meet the schedule. And quality... they will work with you on the pricing, believe me. They do. My customers, at least, they do. Price is important, but they'll work with you. But quality and delivery, they will not. They say, "this is what I want." So if you tell them that you'll deliver the mold on this date. If you deliver them, next time it will be easier for you to get a job from them. But, next, still, the price, I have to go and meet my competition's price. Probably even if we are ten dollars more, they will not (source the job here). We have to be ten dollars less. Even if it is a two million dollar contract. I have to be at least a thousand dollars less than my competition." (R21)

In one case of preferred sourcing observed, the molder had a target price and asked the supplier to build the tools for that amount. The job was not quoted competitively, but neither was there opportunity to negotiate the price:
“We made some special arrangements with (our customer) that we were the preferred source for the molds. When we cannot make the (timing) requirements they will go somewhere else. Otherwise, we will build the molds for them. It was a special arrangement. SMC. Special deal, because of the personal relationship what we have with (the customer’s) program manager. It’s not a corporate handshake or anything like that. It is just an understanding between the people involved. This is what happens, when you have the relationship between the two parties, you can do a lot of things. He trusted us. And we assured him that we will deliver all the molds on time. And our prices were almost fixed to a certain extent. Whatever price they quoted to (their) customer, we get a percentage of it. So there is no negotiation, nothing. Say, for example, if they quoted a hundred thousand dollars. We go back and tell them, “okay we’ll build the tool for ninety-five thousand dollars.” So, ...we get ninety-five thousand dollars. They keep five percent. They give us the ninety-five percent.” (R21)

5.4.5 Contact Between SMC Mold Manufacturers and Their Customers

SMC mold manufacturers typically have no role in the activities of their customers. The one exception observed was a case in which the mold manufacturer filled the role that engineers in the customer’s organization would traditionally have performed. They functioned as a part of the design team and had input in styling decisions for the parts before designs were released. In this role, the mold manufacturer had extensive interaction with the OEM as well:

“The last two programs that I’ve been on, we have went down weekly and sat down with our customer, who’s sitting down with (their customer). In this case, (a heavy truck manufacturer). We go in and sit down with them, as a support to them. We’re in the meeting, only as support or advice if they need it.” (R09)
This type of interaction is uncommon. Typically, the molders prefer to keep their vendors and their customers separated. One reason is to keep the OEM from finding out how much money they make on programs.

"Fiberglass molders do not want you to talk to their customers. Period. Because, ...they have a certain way of pricing things out. They don't want (anyone) to know, other than their own company, how much money they make or what they're getting for it's placement. This is a very competitive business. That's why they don't want us to know how much money they add on to our pricing. If, for example, I quote a mold for a hundred thousand dollars. And probably, they turn around and quote (to their customer) for a hundred and twenty thousand dollars. ...once they get involved with the three of us directly, somewhere or other the pricing will come out. So they safeguard that. ...I can give a typical example for you. There's a tool that we are building for two hundred thousand dollars for (an automotive company). Then, they ask us to get involved with (the automaker) to go for an engineering change meeting. Whenever they do the engineering change on it, they will ask how much it will cost. And, naturally they will look at me and ask how much it costs. So I had to give some numbers to them. The customer won't like it. Because he doesn't have a choice to add or increase his margin on it. (The automaker) will never allow them to make any money on the engineering changes. ...So, that's the reason they do that. It's easier for them to do their business if they don't let us deal with the end user." (R21)

5.4.6 Design Changes Initiated by the Mold Manufacturer

SMC mold manufacturers rarely have any input into design decisions. Again, there was one instance in which the mold manufacturer was a part of the design team, providing the engineering expertise that was lacking in the customer's firm. SMC molders have traditionally had all of the expertise needed in order to ensure that a design was manufacturable and to produce the part once the production tooling had been manufactured. Some of the large
SMC molders are downsizing their engineering staffs, however, and dependence upon manufacturers of tooling and assembly equipment plays a more prominent role in ensuring that the design decisions are appropriate for the process.

5.4.7 Benefits of Good Relationships with Customers

Many SMC molders typically have one or two primary customers that provide them with the bulk of their business consistently. Although the market is very price sensitive, and even preferred mold suppliers may be passed over if they do not submit the low quote, they are often given an opportunity to meet the low bid. This amounts to a “second chance” to get the business.
This chapter presents an integrated analysis of the market segments described in the last chapter. The markets for molds, dies, and compression molds are considered in order to reveal patterns regarding the basis for relationships between buyers and suppliers of dies and molds as well as the involvement of the suppliers in product development activities. The discussion is divided into the dominant themes that emerged from all of the available data, and which appear to be most significant: the dependence of the supplier’s role on the strategic value of the component, and the supplier’s status as the most stable partner in product development. The effects of the changed roles of suppliers and the barriers to and enablers of success in those relationships are then discussed.

6.1 The Strategic Role of Product Components and the Supplier’s Role in Product Development

The likelihood that the relationship between a die or mold manufacturer and their customer will exceed the bounds of traditional customer-supplier
relationships is most dependent upon the strategic role of the components to be manufactured with the supplied tooling. These components are the parts that are associated with styling and are likely to influence the consumer's purchasing decision.

The die and mold manufacturers that are most likely to be selected early or be asked to provide input to design decisions, or both, are those that supply sheet metal stamping dies for automotive body panels or SMC molds for automotive or truck body panels.

A second factor which is very important, but less indicative of the buyer's dependence on the die or mold manufacturer is the characteristics of the manufacturing process. Other factors were considered as well, and although arguments can be made for their applicability, they have less influence. None are as relevant as the marketing value which the component possesses. Some of these alternative interpretations are presented in the following paragraphs.

Level in the Manufacturing Supply Chain. One factor that could indicate the likelihood of a supplier to have input into product development decisions is the tier in the supply chain in which the supplier resides. If this were the case, die and mold manufacturers that supply the OEMs directly would be likely to be included in early product development activities. Second and lower tier suppliers would have little opportunity to influence product development decisions.
While it is true that suppliers are more likely to provide feedback and input to organizations they have a direct relationship with, there were several examples in this study that contradict this explanation.

First, more than one of the mold manufacturers have several customers that are OEMs. Neither the manufacturer of die casting dies nor the manufacturer of injection molds reported having any opportunity to play a part in product development or to be responsible for the design of the components that they build tools for.

The one exception to this occurs when the injection mold manufacturer is responsible for the design of components that will be manufactured in-house. Given the circumstances of this particular example, the company is involved in design and development as a molder and parts supplier, and not as a mold manufacturer. In this case, the mold manufacturing task is a service that is being provided to the production facility by an internal source.

Second, there are several examples of companies performing their role as toolmakers in the second tier who have been asked to provide preliminary input during product development. Two of the stamping die manufacturers have had opportunities to provide preliminary feasibility analysis for automotive body panels when their customers were first tier suppliers to an automotive company. There is also an example of an SMC mold manufacturer that has provided both manufacturability and assembly analysis as well as design input to one of their customers who is a first tier molder. In another
instance, although the mold manufacturer did not have the opportunity to provide design input, they were sourced early by a first tier supplier to build all of the molds for a large program. Such early sourcing is uncommon in that industry, and so it does represent a change in the traditional customer-supplier relationship.

The relevance of the level of the manufacturing supply chain does hold when the die or mold manufacturer is a subcontractor of another tooling manufacturer. In these cases, the die manufacturer responsible to the buyer of the tooling, whether OEM or component supplier, provides the design input or feasibility analysis that has been requested by the customer.

*The level of engineering expertise in the die or mold manufacturer’s firm.* Applicability of this factor as an indicator of extended involvement in customer’s activities would mean that a die or mold manufacturer that has extensive engineering capabilities would have opportunities to provide input to design decisions or product development. Organizations that operate primarily as job shops without having any design or analysis capabilities would not have this opportunity. Neither of these statements is consistently true. The die and mold manufacturers that have more technical expertise are chosen to build tools for more complex parts and parts with tighter tolerances. Their engineering capabilities are valued for their ability to design and build complex dies and molds, and not necessarily for input into the design of the components themselves.
Manufacturing process. This factor was initially believed to be the most relevant, and it is applicable, but has a secondary rather than primary role. Manufacturing processes that require multiple stages, such as sheet metal forming and the manufacture of glass containers, and that are not entirely dependent upon the mold geometry in a single step, are likely to benefit from expertise of the die or mold manufacturer. In these processes, the ability to assess feasibility of a proposed design or to envision the steps that will be necessary in order to manufacture a part is the result of experience. The rules that are followed have not been captured by a neat set of design guidelines that can be used successfully by relatively inexperienced designers.

In fact, personnel who are experienced in the manufacture of sheet metal forming dies and glass molds are more likely to have input during product development. This seems to hold true primarily for parts that have a high styling value, however. Manufacturers of dies for black metal sheet parts have not had the same early or extended involvement with customers as those who provide tools for body panels. This view is substantiated by the fact that all of the stamping die manufacturers produce dies for black metal parts, but none reported early or extensive involvement with customers on those programs. The exception is a captive die manufacturer. There is not sufficient evidence to indicate that their added involvement is due to any factor other than their accessibility because of the fact that they are a co-located captive shop.
Location of the process expertise. Judgement having a foundation in experience is required in order to successfully design and produce a high quality product no matter what the manufacturing process used. The persons best equipped to make the decisions that will result in success varies, depending on the process.

For die cast and molded parts the geometry of the die or mold mirrors the geometry of the finished part. Success in the production of any manufacturable design depends on the ability of the molder or caster to make appropriate choices of the process parameters. In formed parts, however, the decisions rely on knowledge of how the raw material behaves in a sequence of operations in order to choose the appropriate blank shape and the line up of dies that will yield a part having the desired geometry. The die designers and die makers are the people that have that expertise. They make the dies work correctly. The ability to produce the desired part is built into the dies; if the dies are properly set in the appropriate equipment, the process will typically yield good parts.

The reliance of processes on experience and skill rather than on well understood and documented phenomena is also evident in the availability of reliable analytical tools and design rules. In sheet metal forming, these tools are not as widely available or as consistent in providing conclusive information to designers as they have been in the injection molding and die casting processes.
If this factor were dominant, we would expect that manufacturers of dies for most sheet parts, especially deep drawn sheet parts, would be in demand during product development decision making. While this is clearly true for auto body panels, it is not for other sheet metal products, as previously discussed. This also does not explain the demand for more design and development input from SMC mold manufacturers. Although the SMC molding process is not closely linked to the other mold-based manufacturing processes discussed in this report, it does share the traits that the mold geometry mirrors that of the part, and that manufacturing success is dependent upon process decisions that are made by an experienced molder.

*Characteristics of the component.* The previous discussion eliminates the proposed alternative explanations from being applicable to all of the observed cases in determining the likelihood that the interaction between a buyer and supplier of dies or molds will extend beyond that of a traditional relationship.

The parts for which die and mold manufacturers seem to be relied upon for design or product development input are associated with the styling rather than the performance of the consumer product. In addition, it is impossible to

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There were also cases observed in which a manufacturer of die casting dies had some long term, strategic sourcing relationships with customers. In these cases, the item being supplied is a die insert for which there is a repeated, periodic demand. While the manufacture of the item is hardly a high volume process, the demand characteristics are also outside the norm for products in the industry. The discussion in this section does not explain these cases. Because there are no other firms that have products that share the characteristic of repeated demand, it is difficult to propose any defensible argument explaining these cases solely from the data collected in this study. The general supplier literature does address low volume, make-to-order items. It will not be addressed here.
substitute these components with existing parts, and tools for the parts have long lead times.

The long lead times and uniqueness of the components makes it much more critical that any issues that might result in manufacturability problems be addressed as early as possible. Because the components cannot be substituted with those from a previous or an alternative model, the new product cannot be introduced until the process for producing the components is functional. The production life of these components is also shorter than that of components that can be used in several different products with little or no modification. The parts are directly related to the appearance of the final product: and the appearance of the product is one of the primary factors that gives it market appeal. Figure 10 shows the relative importance of the various factors discussed in the various die and mold market segments.

6.2 Stability of the Workforce in Customer Firms

The last section presented an argument that explained where one is likely to find die and mold manufacturers having an increased role in design and product development. But that discussion did not address why those organizations are filling that role. The demand for more extensive services does represent a change, and so there must be some factors in the industry's environment that now makes that change necessary or even acceptable. The argument in this section is based upon the experiences shared by manufacturers of sheet metal forming dies.
The reasons for including die manufacturers during product development and design activities do not appear to be a result of the customer’s strategic effort to improve efficiency during product development. Rather, it is an expedient method of substituting for the lack of experience in their internal design teams. This lack of an experienced design staff has led to problems and poor decisions that have caused delays in previous programs. One would

| Glass Molds     | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| Injection Molds | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Die Casting Dies| 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| SMC Molds       | 1 | 0 | 1 | 0 | 0 | 0 | 1 |
| Stamping Dies/Auto Body| 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| Stamping Dies/Black Metal| 0 | 1 | 0 | 0 | 1 | 0 | 1 |

DM=Die or Mold Manufacturer

- : relevant  : somewhat relevant  : not relevant

Figure 10. Relevance of various factors to the selection and involvement of die and mold manufacturers in various industries
expect that design teams would apply lessons learned during previous programs
to improve efficiency in the future. This hasn’t been the case.

Die manufacturers provided examples of several design concepts they
consider very basic, features that, when included in a design, will introduce
flaws, or that simply cannot be manufactured. For some reason, stylists
continue to include such features in their designs. According to the die
manufacturers, the reason is straightforward: the design teams are young and
inexperienced. There is little continuity of personnel from one program to the
next. True, shorter product introductions have resulted in critical design
features missing because of the absence of complete information when design
decisions are made. However, those problems usually result in integration and
interface issues. The use of features that are not manufacturable is a result of
inexperience and an insufficient understanding of the manufacturing process.

Manufacturers of both stamping dies and SMC molds told of cases in
which the problems that emerged during previous programs had been due to
poor fit between mating parts during assembly, and not to design features that
were not manufacturable. For one of those companies, one of the purposes for
preliminary involvement during design was to address such issues.

Die and mold manufacturers are able to address problems effectively
because they do not have a high rate of attrition among experienced personnel
in their organizations. In fact, among the people that they work with at both
the OEM’s and piece manufacturer’s organizations, they often have the most
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stable workforce. The fact that this issue was a greater factor in sheet metal forming does not imply that designers of parts made with other processes do not have equally high attrition. Again, the design rules and tools in sheet metal forming are not as well defined or as widely applicable as those for some other processes.

The OEM's recognize their dependence upon suppliers to provide input to these early styling decisions. They may not be entirely comfortable with their reliance on die manufacturers, and some are trying to find ways to substitute the use of analytical tools for the experience that is now provided by the supply base.

The evidence indicates that the inclusion of die and mold suppliers during product development is not only for the purpose of compressing the product development period beyond the current norms. Input from these organizations is needed in order to avoid design decisions that will cause costly delays that make the desired schedules impossible to meet.

The use of suppliers to provide design experience is widespread. Parts suppliers that provided data for this study also reported an increased demand for design input due to insufficient experience in the design staff of the customer's firms.

One source of frustration for die and mold suppliers that either perform design activities or review proposed designs for manufacturing feasibility is the lack of authority they have to make decisions regarding the design. They can
make suggestions, but the customer's design staff is under no obligation to accept their advice. When the original design stands, the die manufacturer will sometimes "chase the design," starting with the customer's design and making small adjustments until an acceptable part can be manufactured. To avoid this time consuming, iterative chore, die manufacturers may opt to elevate the problem to higher levels of management within the customer's organization, until they can get support for making the changes they have proposed.

The refusal of staff in the customer's organization to cooperate with suppliers that they have been asked to work with has two sources: either the staff is not pleased with the choice of supplier or they feel that the supplier's expanded role threatens their position. Again, cooperation may be forthcoming only when upper management intervenes after being made aware of the problem.

6.3 Changed Role of Die and Mold Manufacturers: Effects

Five types of scenarios were observed in the data that represent changing roles of die and mold manufacturers. These are:

1. Long term agreements to provide a reliable source for die components that must periodically be replaced.
2. Early sourcing for molds on extremely time-sensitive programs.
3. Early sourcing for dies for automotive body panels accompanied by the die manufacturer's review of the proposed designs for manufacturing feasibility long before designs are released and die construction is launched.
4. Long term strategic sourcing relationships to provide stamping dies for certain components in future programs.

5. Representation on the design team.

Each of the market segments has one or more cases that provide examples of these. Table 7 shows the industries where examples have been observed. The effects of these changes, as reported by the die and mold manufacturers, is summarized in the following sections.

6.3.1 Long Term Agreements to Supply Parts for Which There Is a Repeated Demand

This relationship was observed in suppliers of die casting dies. The repeated demand for identical components, although common in die casting, is not characteristic in the die and mold manufacturing industry. The benefits realized are similar to those present when the part is a product component:

<table>
<thead>
<tr>
<th>Market Relationship</th>
<th>Mold</th>
<th>Stamping Die</th>
<th>SMC Mold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Term Agreement</td>
<td>✓</td>
<td></td>
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<tr>
<td>Repeat Items</td>
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<td>Early Sourcing</td>
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<td>Time Sensitive</td>
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<td>Early Sourcing &amp; Feasibility Analysis</td>
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<td>Strategic Sourcing</td>
<td>✓</td>
<td>✓</td>
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<td>Focus by Part Type</td>
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</tr>
<tr>
<td>Design Responsibility</td>
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</tbody>
</table>

Table 7. Markets where nontraditional relationships are present
economies of scale result in lower costs as efficiency improves. The established long term agreement eliminates the necessity for costly paperwork for both the customer and the supplier.

6.3.2 Early Sourcing for Molds on Extremely Time-Sensitive Programs

Early sourcing was observed on only one program in which it was not accompanied by a preliminary feasibility analysis. A commitment was solicited from the mold source six to nine months early\(^{11}\) at the request of the OEM.\(^{4}\) This was a large and aggressively paced program, and it was important to the OEM that the product be introduced on time.

The mold manufacturer was able to complete the project on time and within the agreed upon budget only because of early sourcing. The ability to plan for a large program in advance allowed the program manager to reserve capacity in vendor's shops so that there would be no delays when work was sent out. In effect, capacity was reserved in-house. No other jobs were solicited to fill hours during the time when the program was scheduled. Work that was to be performed in-house could be planned using regular hours at standard rates. Had there not been a contract in place for the program, other programs would have been obtained to fill the available hours. The use of

\(^{10}\) Before the molds were actually to be launched.

\(^{4}\) The molder was responsible for procuring the tool source, and the mold manufacturer's contract was with the molder, although the OEM did have a preference for that mold source. It should be noted that the molder also was chosen early. Had this not been the case, early selection of the mold source would not have been possible.
overtime hours at premium rates would surely have been needed in order to meet the additional commitments.

6.3.3 Early Sourcing Accompanied by Preliminary Design Review

It is difficult to assess exactly what the financial and temporal effects are of a die manufacturer's involvement in a program. They can compare results with similar programs, but not directly, because there are always differences between programs that affect both the time and cost required to complete the program. There is, however, evidence based on projected savings as presented to the customer, as well as the costs that have resulted when customers have refused to follow suggestions made by die manufacturers early in a program.

Die manufacturers are able to reduce the costs of programs when they have an opportunity to assess the process and designs early simply because there is time to evaluate and incorporate their suggestions without putting the program schedule in jeopardy.

Three different types of input from die manufacturers have an impact on new product introductions:

1. Alert the design team of features in the design that are not manufacturable or will introduce defects into the component.

2. Propose changes to the process of how the component is manufactured that will result in lower tooling costs.\(^4\)

\(^4\)This is primarily for sheet metal forming and has to do with the specification of the die line-up. The number of dies required, or the manner in which operations are performed in order to produce the desired panel, may be modified. In other operations this input may come in the form of changing, say, the tip of the die in order to make the die easier to manufacture.
3. Propose changes to the process used to manufacture a component that will result in lower production costs.

The proposals for changes presented by the die manufacturers must be accompanied either by evidence that a design feature cannot be manufactured or by a forecast of the savings that will be realized if proposed changes are incorporated.

6.3.4 Long Term Strategic Sourcing Relationships for Specific Categories of Tools

The selection of a tooling supplier as a preferred source for certain types of items has the potential of impacting program costs in two ways. First, the die manufacturer is able to become more efficient as their expertise is concentrated in one or two types of systems. Second, it is possible to eliminate much of the cost of paperwork and time in selecting a supplier by bypassing the competitive bidding process.

The first of these two is believed to be a reality, although the effects cannot be measured. The second, unfortunately, is often unrealized because the buyer's emphasis on price in a tooling program often leads them to conduct several rounds of bidding in which the "preferred source" must quote against both internal targets and bids solicited from "competitors" in an effort to beat down the price of their preferred supplier. Sometimes this process merely causes differences in interpretation to surface. At other times, it initiates an ugly bidding war which must be resolved by upper management.
6.3.5 Representation on the Design Team

Die manufacturers that are able to have design input, rather than just manufacturability analysis, have the greatest influence over design. This participation in or responsibility for design was observed only in the automotive industry.\(^{42}\)

The die manufacturer has no influence over the external *styling* of the vehicle. However, whether they work with the customer on the design or have been given complete responsibility for it, they are able to make design decisions for individual components that will affect not only the tooling and manufacturing process, but also the component features that affect the final assembly. This responsibility for the interaction between components and the integration of separate subsystems is unique to die suppliers who provide tooling for a large number of components, perhaps even all of the components for the vehicle body.

6.3.6 Summary

Each of the relationship characteristics discussed above has the potential to reduce tooling costs. Other benefits that may be realized are the reduction of the component cost that results from reducing manufacturing costs, the reduction of lead time for the production tooling, and the reduction of

\(^{42}\) Both passenger vehicles and heavy truck.
procurement costs through eliminating bidding costs and paperwork. The benefits that have been observed are summarized in Table 8.

<table>
<thead>
<tr>
<th>Effect</th>
<th>Reduce Tooling Cost</th>
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<th>Reduce Lead Time</th>
<th>Reduce Procurement Costs</th>
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</table>

Table 8. Effects of nontraditional relationships

6.4 The Expanded Role of Die and Mold Manufacturers: Barriers to Success

Die and mold suppliers value the opportunity to service their customers beyond the customary die build functions and work very hard to maintain their status as a preferred source. Occasionally, situations arise that create tension between the two parties. Surprisingly, even when customers have
damaged the relationship, there is almost no risk that they will lose a supplier.

Some of the behaviors that frustrate die and mold manufacturers\(^4\) and create tension in relationships that they have with their customers include:

- putting the supplier between groups within the customer’s organization that have conflicting goals
- using a traditional bidding process that consists of several rounds of competitive quoting in order to establish prices
- being unwilling to price programs fairly when a supplier has displayed a commitment to increase efficiency
- expecting to benefit when suppliers perform well, yet being unwilling to share in the costs that suppliers incur when solving unforeseen problems
- failing to place consistent levels of business with a supplier that is performing well

6.5 The Expanded Role of Die and Mold Manufacturers: Enablers of Success

The cases presented in the last chapter showed that even when buyers of dies and molds give a die or mold manufacturer status as a preferred supplier or enter into a strategic sourcing relationship with the supplier, they still maintain

\(^4\)Only one case was observed in this study in which there was a buyer in the market that a mold manufacturer refused to do business with.

\(^4^4\)This discussion is conspicuously one-sided. The barriers to successful nontraditional relationships related here all describe behaviors of the customer. Die and mold manufacturers did relate things that are done within their firms that cause problems in relationships with customers, but these didn’t appear to be problems with firms that have been given status as a strategic or preferred supply source. Presumably, the customer has found their performance satisfactory before initiating an alliance. Additionally, since the information was provided by the supply base, it is not surprising that criticisms focus on customer behaviors.
the power in the relationship by displaying their ability to go elsewhere if the conditions are favorable. This was observed in almost every case. A relationship with a “valued” supplier is sacrificed if there is a potential for savings existed, even if the amount invested in procuring the alternate source and placing the work exceeded the amount saved.

Respondents discussed only one situation in which the supplier felt that the buyer was concerned about their long term well being and their ability to service the customer long term. The demonstration of a commitment from the buyer certainly was essential to the success of that relationship.

Although other die and mold manufacturers did not have such dependably stable relationships with their customers, several factors recognized by respondents stood out as contributing to a successful, long term commitment in a sourcing relationship. These include:

- the presence of a stable staff in the buyer’s purchasing organization
- personal relationships between personnel in the buyer’s and supplier’s organizations
- a history of success in previous programs
- the supplier is able to make formal proposals that will result in savings to the buyer
- the buyer considers the entire cost to the new product introduction that is associated with the supplier’s product, rather than just the price of that item
- the buyer is willing to share in the risks that suppliers take when they attempt to reduce costs and lead time
- elimination of the competitive bidding process
• pricing levels that will ensure the ability of the supplier to invest in improving their internal processes

• willingness on the part of the buyer to pay for services they request that are outside the scope of the contract

\[4\] This doesn't mean that the supplier will charge for additional services. However, an attitude in which the buyer is always expecting something for nothing or exploits the supplier needlessly will destroy trust.
CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

The role of die and mold manufacturers during product development has expanded in some arenas, primarily in the automotive industry. Manufacturers that produce tools for automotive body panels have been the primary beneficiaries of the changes. The factors that affect the tooling suppliers' likelihood to participate in product development activities, and the effects of their participation are summarized in Figure 11.

The demand for input from tooling suppliers during the design stage is made necessary by the shrinking pool of experience in the customers' companies.

Both the buyer and supplier of tooling can benefit from early sourcing and involvement of die manufacturers in product development. The supplier is rewarded by having a longer planning horizon and an assurance of future work. The buyer profits from the savings that result from more robust component designs and processes.
Although a stable, long-term strategic partnership has the potential to make both parties better able to compete in the market, the two do not share equally in the profits of the relationship. The buyer maintains the position of power, and the supplier, who will try not to damage the relationship at all costs, is at the mercy of the buyer. This is in direct contradiction to the buyer’s need for the supplier’s input. Instead of treating the supplier as a valued source of a necessary product, the buyer behaves as if the item being supplied is an off-the-shelf commodity, beating down prices until the supplier’s profits are insufficient to support the continued investment in facilities and processes that differentiated them from their competitors and allowed them to
become a preferred source. Only suppliers that refuse to accept work at a loss can continue to improve the efficiency of their operations, though they risk losing business for which they had been preselected as a strategic supplier.

Surprisingly, captive tooling suppliers are not more likely to have a role in early design and manufacturing decision making than their independent competitors who have non-traditional roles. Parent companies benefit from having captive tool shops primarily because they will always be responsive when work needs to be expedited in order to meet production commitments.

7.2 Implications

This study focused on suppliers of dies and molds. The findings, however, have broader implications to the involvement of component suppliers in product development as well. Conventional wisdom dictates that suppliers be included in product development activities because they, as the manufacturers of the product components, can provide input that will result in more manufacturable and robust part designs. The primary goal that drives the approach is speeding product introduction: more robust initial designs will lead to fewer design revisions and engineering changes. The design teams that complement the suppliers are to be interdisciplinary and cross-functional.

What was observed was a system in which separate functional groups are poorly integrated and each group protects its own priorities, which are likely to conflict with the priorities of the other groups. The only party that has been able to interact with all of these groups and propose approaches that meet all
of their opposing objectives is the supplier. The suppliers are included in the process not only to provide input to the design teams, but to lend the voice of experience to guide unseasoned design teams. If the supplier has been involved with previous programs, they are often the ones who keep the customer from falling into the same traps that have been encountered in the past. Additionally, suppliers often incorporate expertise that has been gained when working with other, more technically advanced customers, in effect transferring technology between customer organizations.

The designers resent having to share their responsibilities with more experienced personnel outside their organizations, sometimes even refusing outright to cooperate with suppliers that have been given the responsibility to design a component or system. The supplier's involvement directly threatens their positions.

This theory explains the findings of previous studies which concluded that supplier involvement in product development had a detrimental affect on new product introductions. The respondents in these studies were product development personnel from the buyer's organization. These are the very people that find the supplier's expanded role unwelcome.

Furthermore, in an industry that produces a complex product and is characterized by downsizing, the expertise required to develop new products will have to come from the vendors. The availability of experienced staff and thus the carry-over of information from one program to another will be
dependent upon stable relationships between buyer and supplier. The problem is finding an appropriate way to capture and retain knowledge so that it can be readily applied in the future. Thus far, the most effective way of doing this has been to have a consistent experience base in the workforce. Usually, that workforce stability is much greater in supplier companies than in the buyer's.

If, like the automotive industry, the market is dominated by a few large players, it is critical that a healthy supply base of experienced staff be available. Any measures that could result in a shrinking supply base will make experience rare, and manufacturers will have to compete for a small number of skilled vendors in order to stay competitive and meet their ambitious product introduction schedules. Companies that do not nourish relationships with committed and able suppliers may find themselves without the skill base they need to develop and introduce new products quickly.

7.3 Recommendations to the Die and Mold Manufacturing Industry

Die and mold manufacturers still compete against each other for the majority of business. In spite of strategic sourcing relationships and preferred supplier status, tooling suppliers are chosen primarily on the basis of price. There are, however companies in the industry that are able to thrive and grow while having competitive, but not rock bottom, pricing. These companies had a consistent customer base, sometimes accompanied by growing shares of business from primary customers. They also often were comfortable with their competitive position in the market, and less protective of their strategies for
success. The primary characteristics of those companies, in contrast to others, include:

- a focus on a particular type of product, on a particular customer base, or both
- ability to clearly communicate key strengths and competitive advantages
- a deliberate effort to continuously improve efficiency
- a tendency to innovate and experiment with unconventional methods, even when the implications of success would force change beyond their own organization
- willingness to share savings with the customer when programs are completed well below the contracted price

7.4 Recommendations for Future Research

This research generates several interesting questions that require further investigation. Because the case study method was used, the findings are a direct result of the characterization of the companies that participated. While every effort was made to include a broad cross section of the industry, the applicability of the findings of this study to some specific types of companies should be investigated.

For example, it was discovered that manufacturers of tooling for components that have a strategic value in the style of a consumer product were more likely to be involved in product development. In this study, that group did not include manufacturers of plastic injection molds. There are, however, many plastic components of automobiles and other products that share those
qualities. The applicability to those types of companies should be further investigated.

Another topic of interest that was not addressed in this research is the fact that die and mold manufacturing firms are small businesses. The qualities that were displayed by many of the firms, such as a reliance on other firms to provide excess capacity during periods of peak demand, a mutual dependence on other firms in the industry when implementing new technology, and the importance of personal relationships in winning orders and ensuring future work, are characteristic of small businesses. The applicability of the research on small businesses to the problems faced by the die and mold industry should be investigated. Additionally, the findings of this research may be relevant to small businesses in other industries.

Die and mold manufacturers have taken measures to improve efficiency primarily as a response to shrinking lead times and pressures to reduce costs. However, because the aggressiveness of new product introduction schedules has been accompanied by an increasing volume of engineering changes, expedited schedules and long hours are the norm. When used long term, this approach to meeting delivery dates has a negative impact on efficiency. The relationship between lead times, design accuracy, and efficiency during peak demand periods should be characterized, so that product introductions can be optimized.
BIBLIOGRAPHY


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Thank you for considering my request to include your organization in my research study. I look forward to working with you to plan a visit to <Company>. Your help and <Company>'s participation will assist me in completing my research on practices in the die and mold industry. This letter follows our conversation of <Date of Contact via Telephone>, and will provide additional information regarding my research, and what <Company>'s participation would entail.

Attached is a brief summary of the objectives and approach for this study. It describes the type of information I would be gathering, as well as the individuals I would be interested in talking with. A primary objective of this study is to gain an understanding of the interaction of die makers with their customers, and the impact this has on your business. Therefore, access to any persons who could help complete a picture of how <Company> works to satisfy the needs of your customers would be appreciated.

I anticipate that each interview will take between sixty and ninety minutes. I will of course be mindful of the time constraints of all individuals. In order to increase efficiency and accuracy during data collection, I tape-record the interviews, with the approval of the individual interviewee. One visit with each person should be sufficient. If clarification is later required for any specific information, it will be addressed via telephone at a later date; this should take no more than fifteen minutes.

The study I am conducting is fairly deep, and I understand the need to protect information that is sensitive to your firm and to the individuals I interview. The information that I collect will be used only for my dissertation research. I will be the only person responsible for collecting information and the only person who has access to it throughout the study. All data will be handled in accordance with Ohio State University's guidelines and any agreement required by your organization. In addition, any descriptive information about <Company> that will be included in the final report of this study will be circulated to you for your approval.

As we discussed, I will call you within the next few days to address any questions you may have. I hope you will agree that <Company> will benefit from this study, as well. Thanks again for your help.

Best regards.

Althea Gill
Research Fellow
Investigation of the Effect of Customer-Supplier Relationships in the Die and Mold Industry on the Introduction of New Products

Research Summary

Althea Gill
The Ohio State University
Department of Industrial, Welding & Systems Engineering
Phone 614-688-9240 FAX 614-292-7852 e-mail gill8@osu.edu

Background. The pressures of time, cost, and quality impact firms throughout the manufacturing supply chain. The services that OEMs purchase from their suppliers has changed drastically in recent times, resulting in changes in the supplier organizations. The services that OEMs and component suppliers demand of die and mold makers vary widely. Previous visits with die and mold makers have revealed that the nature of interactions with their customers is changing, and that issues that arise at the customer-supplier interface are directly responsible for many of the obstacles to optimizing productivity. Managing the relationships with and expectations of customers has become more important, and has impacted die/mold organizations in several ways.

The research. This research involves the study of customer-supplier relationships in the die/mold industry. This topic is interesting because characteristics of the die and mold industry differ from those of product component suppliers. The changing role of component supply firms in the U.S. and the resulting impacts on productivity and quality have been widely studied from the buyer's point of view. Studies that address the impact on supplier firms are limited, and none address firms that supply inputs other than product components. Thus, this study will address these previously unaddressed areas by investigating how change is affecting the die and mold industry and how die and mold organizations are impacting the practices of their customers.

The primary reasons for this study are (1) short product life cycles will encourage more formal relationships, the demand for more extensive services, and shorter lead times, a framework for successful relationships is necessary, and (2) dies and molds are high cost items that have long lead times, therefore it is advantageous to identify ways of reducing costs and lead times. It will be necessary to determine how the practices of and interaction with customers affect these productivity measures.
The objectives of this research are (1) to model the interaction of die and mold makers with their customers, including information flows, communications, services provided throughout the project, and participation in product development activities. (2) to identify current product development practices that may serve as obstacles in the design and fabrication of dies and molds, preventing the expeditious introduction of new products. (3) to determine how changes in product development practices are impacting die and mold makers, and (4) to propose changes in the strategies of the organizations involved that will aid in optimizing the product development process.

Proposed strategy and approach. The research objectives will be accomplished by analyzing the interactions between die and mold organizations and their customers. Data will be collected via site visits and personal interviews at die and mold companies.

Participating companies will be chosen for breadth. representatives will be sought from both captive and independent die/mold companies, firms that service different industries, and companies of different sizes. Site visits will be made to firms and interviews conducted with personnel who have interacted with customers, provided input to customer products and processes, and implemented procedures required by customers’ policies. The information gathered will focus primarily on the history of relationships with customers, services requested and provided, flow of information between companies, involvement in the product development activities of customers, and the progress of projects (both completed and in progress).

Benefits. The goal of this project is to make an important contribution to the theory and practices of managing customer-supplier relationships when the purchased inputs to manufacturing are not product components. The results will be useful and interesting to both die and mold makers and purchasers of dies and molds. They will be able to identify the strategies that will best serve them in reaching their goals. These businesses will be better able to quantify how changes in their operations will affect the costs and lead times of dies and molds. Knowledge will be gained regarding the capabilities that will be needed by the die and mold organizations in order to compete in a changing marketplace.

Confidentiality. The identity of participants (both companies and individual respondents) and specifics of any data considered business sensitive will be held in strict confidence. All performance-based data will be normalized over the entire study. Individual case descriptions will be circulated to respective participating firms for approval before publication of the results.

Deliverables. All participating organizations will receive a report of the results (the dissertation) when the study is completed (December, 1997).
Investigation of the Effect of Customer-Supplier Relationships in the Die and Mold Industry on the Introduction of New Products

Pre-interview Briefing for Respondents

The Ohio State University requires that I disclose the nature of my research, answer any questions you might have, and obtain your consent before I gather any data from you. The interview I will be conducting will be only for the purpose of gathering data for my dissertation research. I will be the only person who has access to the audio tapes recorded during the interview if you grant permission for the interview to be taped. In addition, any raw notes or transcripts will be used only by me. The tapes will be destroyed by me in the presence of my dissertation advisor at the conclusion of the study. The identity of organizations taking part in the study will be known only to myself and Professor Rajiv Shivpuri, my dissertation advisor. Your identity will be known only to me. The information you provide will not be identified with you or the organization you represent.

During this interview, I will be asking several questions about your firm, typical business activities, and relationships you have with customer and vendor organizations. I will also be asking you to discuss obstacles your organization has faced in the course of doing business. Not all of the questions will be in your area of expertise. However, you should answer them as best you can and explain any reservations you have regarding the information you provide. If any of the information is sensitive to you or your firm, it will be kept in strict confidence. Not all of the data you provide will be used in the reporting of this study. Much of the information will be used only to capture your perspective and provide a basis on which I can conduct an analysis. It will, however, be important that you share a realistic view of your firm’s performance and the challenges you face so that a fair and thorough analysis is possible. This being said, I must tell you that you may refuse to answer any question(s) at your discretion.
After I have had an opportunity to write a description of the relevant information provided by respondents in your firm, it will be circulated to designated person(s) in your firm so that you can verify that it in no way identifies or jeopardizes your organization or any of the respondents that have provided information. You then have the right to deny permission for any specific information you have provided to be published in the final reporting of this research. A copy of the dissertation will be made available to you at the conclusion of the study.

You have previously been given a summary describing the research project:
   Have you had an opportunity to read it in its entirety?
   Do you want me to review it with you before we begin?
   Do you have any other questions that you would like answered before we begin?
   Do I have your permission to tape this interview?

Your written consent is required by the university. It ensures that you understand the extent of your participation in this research and have the right to withdraw your participation at any time. It also protects me by providing evidence that I have not fraudulently or surreptitiously obtained the data used to complete my degree requirements.
CONSENT FOR PARTICIPATION IN
SOCIAL AND BEHAVIORAL RESEARCH

I consent to participating in the research entitled:

Professor Rajiv Shivpuri or his authorized representative (Ms. Althea Frances Gill) has explained the purpose of the study, the procedures to be followed, and the expected duration of my participation. Possible benefits of the study have been described as have alternative procedures, if such procedures are applicable and available.

I acknowledge that I have had the opportunity to obtain additional information regarding the study and that any questions I have raised have been answered to my full satisfaction. Further, I understand that I am free to withdraw consent at any time and to discontinue participation in the study without prejudice to me.

It has been explained to me that my identity will be known only to my employers and the Principle Investigator and his authorized representative, and that the information I provide will be kept confidential from everyone (including my employer or his representatives) and will be used only by the Principle Investigator and his authorized representative.

Finally, I acknowledge that I have read and fully understand this consent form. I sign it freely and voluntarily. A copy has been given to me.

Date: ___________________________ Signed: ___________________________

Signed: ___________________________ Signed: ___________________________
(Principle Investigator or his Authorized Representative) (Person Authorized to Consent For Participation—if required)

Witness: ___________________________
Interview Protocol

ORGANIZATIONAL CONTEXT

Describe your organization. (Physical facilities, product sales volume, labor force, production control strategy)
Manufacturing, production technology, work organization, work in progress
Describe your marketing activities
Describe your customer base
What are the services typically provided by your firm?
What services are typically subcontracted by your firm?
Describe your investment decisions over the past several years
Describe changes made in your internal operations management procedures in recent years

STRATEGY ISSUES

Describe your organization’s competitive strategy
How do your strategy and operations differ from those of your primary competitors?

TYPICAL BUSINESS ACTIVITIES

Describe a typical die project from bid preparation through delivery to the customer
Describe any customer requirements that have presented obstacles within your organization.
What are your requirements for accepting a job? Describe the types of jobs that have the technological capabilities and capacity to perform that you would reject

PROJECT DEVELOPMENT ACTIVITIES

Are your firm’s activities typically well integrated into the overall development projects of your customers?
Have you participated in a development project in which you have had significant engineering input before the product specifications and design were completed? Describe your involvement throughout that effort:

- What are the important issues in managing this type of project?
- What difficulties/obstacles did you encounter?
- What would you have done differently?
- What would you have liked your customer to do differently?
- Was there open sharing of sensitive information by the customer?
- How did the engineering competence of the customer affect your participation in the project? Your ability to meet cost and delivery targets?

EVOLUTION OF RELATIONSHIPS WITH CUSTOMERS

What major strategies do you use when dealing with new customers? With long-term customers?

Consider one of your long-term customers. Describe how interaction with the customer has changed over the course of that relationship.

Does the competitive strategy of your customer affect how they 'manage' the activities performed by your firm? Explain.

Give an example of how the requirements of a customer have ever had a significant impact on the manner in which you have managed a project or operate your firm?

What factors are most important in maintaining an ongoing relationship with a customer?

What preferential treatments do you give to your favored customers? What do you get in return?

COLLABORATION WITH OTHER FIRMS

Do you ever collaborate with other firms in order to complete a project? If so, describe the relationship and your interaction throughout the work.

Have your customers ever requested that you share technical expertise with a competitor whom they also use as a supplier? How did you (or would you) respond to such a request?
IMAGE EVALUATION
TEST TARGET (QA-3)

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1.1
1.25
1.4
1.6

1.0
1.1
1.25
1.4
1.6

150mm

6"

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