AN EXPLORATORY STUDY INTO THE MANUFACTURING STRATEGIES IN THE TURKISH MACHINE MANUFACTURING INDUSTRY

by

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AN EXPLORATORY STUDY INTO THE MANUFACTURING STRATEGIES IN THE TURKISH MACHINE MANUFACTURING INDUSTRY

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ABSTRACT

This study has been accomplished to determine the current status of the machine manufacturing industry in Turkey to evaluate different manufacturing strategies employed by the companies operating in that industry.

The study is based on data from a joint project of Machine Manufacturers' Association (MİB), Turkish Technology Development Foundation (TTGV), Turkish Industrialists' and Businessmen's Association (TÜSİAD) and Sabancı University. The data is obtained from a survey targeting all the members of MİB.

There are three basic components comprising a manufacturing strategy. These are *competitive priorities*, that enable the differentiation of the firm from its competitors; *manufacturing objectives* consistent with the competitive priorities; and *action plans* for supporting the manufacturing objectives and thus the competitive priorities at the operational level.

The companies participating in the survey have evaluated 15 competitive priorities, 16 manufacturing objectives and 35 action plans on a 1-5 Likert scale. Competitive priorities and manufacturing objectives have been evaluated with respect to their relative importance for the company for the next two years. Action plans have been evaluated through two questions: one asking for the assessment of the companies concerning the emphasis they have placed on the action plans within the past two years and the other asking about the ranking of the most important 7 action plans for the next two years.

The variables representing these components of the manufacturing strategy are grouped using factor analysis for each component. Competitive priorities are grouped into 4 factors, manufacturing objectives into 5 factors and action plans into 6 factors.

For the first two components, companies are grouped into clusters according to their responses to the same questions. Differences between company clusters within a component are explored using multivariate data analysis techniques. Mean scores of the questions in a particular component are used to determine a statistically significant difference between company groups. Different company groups applying different manufacturing strategies have been defined.

To assess whether companies' selection of manufacturing objectives are consistent with their competitive priorities, clusters achieved by analyzing competitive priorities are fixed and manufacturing objectives are used to determine the differences between these clusters. Results indicate to a certain level of consistency.

ÖZET

Bu çalışmanın amacı; Türkiye'de makina imalatı sektörünün mevcut durumunu belirlemek ve uygulanan farklı stratejileri değerlendirmektir.

Çalışma, Makina İmalatçıları Birliği (MİB), Türk Teknoloji Geliştirme Vakfı (TTGV), Türk Sanayici ve İşadamları Derneği (TÜSİAD) ve Sabancı Üniversitesi'nin ortaklaşa yürüttüğü bir projeden elde edilen verilere dayandırılmıştır. Veriler, MİB üyesi firmaları kapsayan bir anket çalışması sonucu elde edilmiştir.

İmalat stratejisinin belirlenmesinde 3 temel unsur gözününe alınmıştır. Bunlar, firmaların sektördeki diğer firmalardan farklılaşmalarını sağlayacak rekabetçi önceliklerin belirlenmesi, bu rekabetçi önceliklere uygun olarak imalatta performans hedeflerinin belirlenmesi ve hedeflere ulaşmayı sağlayacak uygun aksiyon planlarının seçilmesidir. Sektörün genel durumunu ortaya koymak ve gerek Türkiye'de diğer sektörlerde gerekse yurtdışında benzer sektörlerde yapılmış çalışmalarla karşılaştırmayı sağlayabilmek için öncelikle stratejinin bu 3 temel bileşenine ait genel istatistiksel değerler incelenmiş ve sonra ayrıntılı analizlere girilmiştir.

Sıralanmış 15 rekabetçi öncelik, 16 imalatta performans hedefi ve 35 aksiyon planı ankete katılan firmalar tarafından 1-5 ölçeğinde değerlendirilmiştir. Rekabetçi öncelikler ve performans hedefleri önümüzdeki 2 yıl için önem derecelerine göre değerlendirilirken aksiyon planları geçtğimiz 2 yılda uygulanıp uygulanmadığına ve sağlanan katkı derecesine göre değerlendirilmiş ve önümüzdeki 2 yılda uygulanacak ilk 7 aksiyon planı seçilmiştir.

Faktör analizi yardımıyla stratejiyi belirleyen bu unsurlar gruplanmıştır. Rekabetçi öncelikler 4 faktör, imalatta performans hedefleri 5 faktör ve aksiyon planları da 6 faktör ile ifade edilmiştir.

Kümeleme analizi yardımıyla firmalar gruplanmaya çalışılmış, bunun için yine rekabetçi öncelikler ve imalatta perfromans hedefleri ilgili sorulara verdikleri cevaplardan faydalanılmıştır. Gruplar arasındaki farklılıklar çok değişkenli veri analizi teknikleri yardımıyla incelenmiştir. Faktör analizleri sonucu elde edilen soru gruplarına verilen cevapların ortalamalarının istatistiksel olarak karşılaştırılması sonucu her grupta yer alan firmalar arasındaki farklılıklar ortaya konmuş ve grupların rekabetçi öncelikler ve imalatta performans hedefleri bakımından uyguladıkları farklı stratejiler ortaya çıkarılmıştır.

Analizin ikinci aşamasında rekabetçi önceliklere göre elde edilmiş firma grupları sabit tutularak bu kez aynı firmaların imalatta performans hedefleri bakımından benzerlikleri incelenmiştir. Bu çalışmanın sonucunda grupların genel olarak rekabetçi önceliklerine uygun performans hedefleri belirledikleri görülmüştür.

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1. INTRODUCTION

1.1. Scope of the Study

The main concern of this master thesis is the identification of key structural features of the machine manufacturing industry in Turkey that determine the strength of the competitive forces and profitability in this industry. The state of the competitive strategies in the Turkish machine manufacturing industry is explored using the data through a survey conducted among the member companies of the Machine Manufacturers' Association in Turkey.

Competitiveness is a relative concept in the sense that a company's competitiveness is determined largely by the competitiveness of its competitors. Therefore it is important to be aware of the current and the expected state of the business and the technology environment for developing successful competitive strategies. Chapter 2 gives an idea about the related literature on strategy and competitiveness.

Chapter 3 starts with an introduction to the research methodology by describing the survey methodology used, which is the starting point of the study. After a brief explanation of survey questions, general statistics about survey results are summarized. Comparisons of Turkish machine manufacturing industry with the other sectors of the Turkish manufacturing industry and with the manufacturing industries in other countries are also presented in this chapter.

Chapter 4 starts with a brief explanation of factor analysis that is used to analyze the survey results. The results of applying factor analysis to each component of the manufacturing strategy are reported under three main headings.

Chapter 5 reports on the results of applying cluster analysis to the first two components of manufacturing strategy: Competitive priorities and manufacturing objectives. A short introduction to cluster analysis is given.

A conclusion of the study is provided in Chapter 6 summarizing the results achieved.

2. RELATED LITERATURE REVIEW

2.1. The Strategy Concept

Strategy has to do with deploying resources against an opponent. The word originally comes from the Greek *strategos* meaning a general or a commander of troops. In business, strategy refers broadly to a marshaling of our economic resources to succeed in the competitive struggle (Lasher, 1999).

A strategy is the pattern or plan that integrates an organization's major goals, policies and action sequences into a cohesive whole (Quinn, 1996).

Rumelt (1996) defines the term strategy as a set of objectives, policies and plans that taken together define the scope of the enterprise and its approach to survival and success.

Mintzberg (2001) proposes to look at five different meanings of strategy and their interrelationships. These are plan, ploy, pattern, position and perspective. Considering his definitions as a whole, Mintzberg argues that no one definition should be preferred to the others. In some ways they compete as substitutes for one another. But perhaps in more important ways they are complementary.

Ansoff (2001) proposes four strategy components to provide a practicable method of establishing a common thread between past and future activities. His 'components of strategy' approach was innovational at the time and has been imitated since. Proposed four strategy components are:

- *Product market scope,* which is an industrial listing so delimited as to confine strategic search to the similar and familiar.
- *Growth vector,* describing how the firm can expand, within and beyond its present field.
- *Competitive advantage,* specifying what the firm has, or needs, to compete effectively.
- *Synergy,* a desirable condition of complementarities between new and existing product-market activities.

Digman (2001) considers that any strategy has four components and lists these as:

- The scope or domain of action within which the organization tries to achieve its objectives.
- The skills and resources that the organization will use to achieve its objectives – its *distinctive competence*.
- Advantages the organization expects to achieve over its competitors through its skill and resources deployments – its *competitive advantage*.
- Synergies that will result from the way the organization deploys its skills and resources.

Digman (2001) gives four levels of strategy: enterprise, corporate, business-unit and functional / operating. Their applicability and main distinguishing features are shown in Table 2.1.

Table 2.1. Strategy levels *(Digman, 2001)*

Strategy Types	**Applies to**	**Focus**
Enterprise	All organizations	Mission, purpose, role in society
Corporate	Multibusiness organizations	Which businesses and their interrelationships
Business unit	All organizations	How to compete most effectively
Functional / operating	All organizations	Functional and operational business-unit support

Lasher (1999) gives the idea of strategic hierarchy as follows:

- Corporate strategy
- Line of business (competitive) strategy
- Functional area strategy
- Operating (department) strategy

Corporate strategy is the pattern of decisions in a company that determines and reveals its objectives, purposes or goals, produces the principal policies and plans for achieving those goals and defines the range of business the company is to pursue, the kind of economic and human organization it is or intends to be and the nature of the economic and noneconomic contribution it intends to make to shareholders, employees, customers and communities (Andrews, 1996).

Lynch (2000) defines three core areas of corporate strategy:

Strategic analysis: The organization, its mission and objectives have to be examined and analyzed.

Strategy development: The strategy options have to be developed and then selected.

Strategy implementation: The selected options have to be implemented.

There is considerable overlap between the three core areas, which are separated out for clarity but in practice, may operate concurrently.

Manufacturing affects corporate strategy and corporate strategy affects manufacturing, even in a routine operating area such as a production scheduling system. When companies fail to recognize the relationship between manufacturing decisions and corporate strategy, they may become saddled with seriously noncompetitive production systems, which are expensive and time-consuming to change (Skinner, 1969).

According to Quinn (1996), effective formal strategies have the following elements essentially: (1) the most important goals or objectives to be achieved, (2) the most significant policies guiding or limiting action and (3) the major action sequences or programs that are to accomplish the defined goals within the limits set.

Rumelt (1996) defines two different methods of strategy evolution. The so-called generic strategy deals with the basic mission or scope of the business. It can be analyzed by looking at the changing economic conditions over time. The competitive strategy, on the other hand, focuses on differences among firms across time and gives importance to the firm's special competitive position. The differences between these concepts are summarized in Table 2.2.

Table 2.2. Generic versus competitive strategy *(Rumelt, 1996)*

	Generic Strategy	*Competitive Strategy*
Value Issue	Social Value	Corporate value
Value Constraint	Customer Value > Cost	Price > Cost
Success Indicator	Sales growth	Increased corporate growth
Basic Strategic Task	Adapting to change	Innovating, impeding imitation, deterring rivals
How Strategy Is Expressed	Product-market definition	Advantage, position and policies supporting them
Basic Approach to Analysis	Study of an industry over time	Comparison across rivals

2.1.1. Strategic Planning

Strategic planning (also known as long-range planning) began to gain widespread momentum and popularity in the 1960s and reached its peak during the 1970s. Much of the process was driven by mathematical models, which were designed to determine what outputs should be obtained from a given set of inputs (Boxwell, 1994).

Modern business strategy traces to the works on administrative policy of Kenneth Andrews and his colleagues at Harvard. Viewing business strategy as the match a business makes between its internal resources and skills and the opportunities and risks created by its external environment, they developed the SWOT framework: Strengths, Weaknesses, Opportunities and Threats. In this framework, the Chief Executive Officer

(CEO) is in charge of the process of strategy formation, and main task of corporate-level strategy is identifying businesses in which the firm will compete (Hunt, 2000).

At about the same time, a few of the management consultancy firms developed some ground rules and strategic planning tools to enable their large corporate clients to better understand corporate strategy issues facing their business.

Ansoff (2001) sees strategic planning as merely a rational approach to assessing and redefining the linkages of the firm with both its business and societal environments, while 'strategic management' is seen as the activity that will both discern the external possibilities and bring about the appropriate capability changes.

Toward the end of 1970s, Porter introduced in his book *Competitive Strategy* the concepts for analyzing industries and the competitors within them in understandable form.

Since both the analysis and the development of a strategy are rather complex in nature, they need to be split into a series of analyses. Porter's value chain can be used as a starting point for these studies. (Figure 2.1)

The value chain is a systematic approach to analyze the development of competitive advantage in a firm. Porter introduced it in his book, *Competitive Advantage* (1985). The chain consists of a series of activities that create and build value. They culminate in the total value delivered by an organization. The 'margin' depicted in the diagram is the same as added value. The organization is split into 'primary activities' and 'support activities'.

According to Porter (1985), the primary activities are:

Inbound Logistics activities involve relationships with suppliers and include all the activities required to receive, store, and disseminate inputs. Here goods are received from company's suppliers. They are stored until they are needed on the production/assembly line. Goods are moved around within the organization.

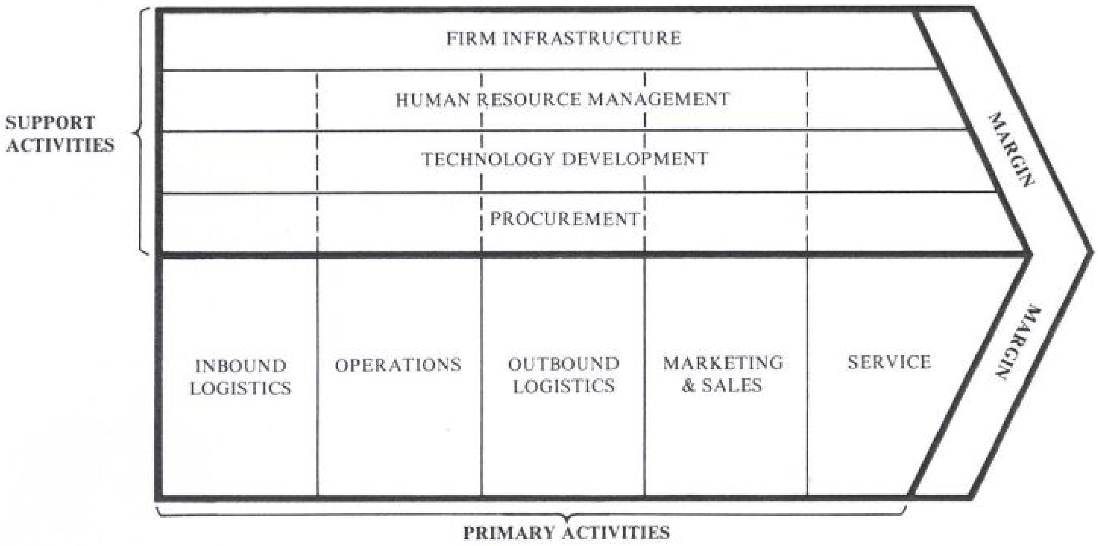


Figure 2.1. Value chain *(Porter, 1985)*

Operations are all the activities required to transform inputs into outputs (products and services). This is where goods are manufactured or assembled. Individual operations could include room service in a hotel, packing of books/videos/games by an online retailer, or the final tune for a new car's engine.

Outbound Logistics activities include all the activities required to collect, store, and distribute the output. The goods are now finished, and they need to be sent along the supply chain to wholesalers, retailers or the final consumer.

Marketing and Sales activities inform buyers about products and services, induce buyers to purchase them, and facilitate their purchase. In true customer orientated fashion, at this stage the organization prepares the offering to meet the needs of targeted customers. This area focuses strongly upon marketing communications and the promotions mix.

Service includes all the activities required to keep the product or service working effectively for the buyer after it is sold and delivered. This includes all areas of service such as installation, after-sales service, complaints handling, training and so on.

Support activities are:

Procurement is the acquisition of inputs, or resources, for the firm. This function is responsible for all purchasing of goods, services and materials. The aim is to secure the lowest possible price for purchases of the highest possible quality. They will be responsible for outsourcing (components or operations that would normally be done in-house are done by other organizations), and e-Purchasing (using IT and web-based technologies to achieve procurement aims).

Human Resource management (HRM) consists of all activities involved in recruiting, hiring, training, developing, compensating and (if necessary) dismissing or laying off personnel. Employees are an expensive and vital resource. An organization would manage recruitment and selection, training and development, and rewards and remuneration. The mission and objectives of the organization would be driving force behind the HRM strategy.

Technological Development pertains to the equipment, hardware, software, procedures and technical knowledge brought to bear in the firm's transformation of inputs into outputs. Technology is an important source of competitive advantage. Companies need to innovate to reduce costs and to protect and sustain competitive advantage. This could include production technology, Internet marketing activities, lean manufacturing, Customer Relationship Management (CRM), and many other technological developments.

Infrastructure serves the company's needs and ties its various parts together, it consists of functions or departments such as accounting, legal, finance, planning, public affairs, government relations, quality assurance and general management. This activity includes and is driven by corporate or strategic planning. It includes the Management Information System (MIS), and other mechanisms for planning and control such as the accounting department.

2.1.2. Competitive Strategy

The type of economic competition has changed rapidly over time. Competition is not static anymore and success or failures do not only depend on production factors. More and more companies join the pool of economic competition every day and new technology, new products, new markets and new management concepts shape the competitive advantage (Li, 2000). The success of the Japanese companies in penetrating foreign markets has placed competitive strategy in spotlight.

Developing a competitive strategy is developing a broad formula for how a business is going to compete, what its goals should be, and what policies will be needed to carry out these goals. Different firms have different terms for some of the concepts illustrated. For example, some firms use “tactics” instead of “operating” or “functional policies”.

The ultimate purpose of strategic management is to focus an organization’s resources, capabilities and energies on building a sustainable advantage over its competitors along one or more dimension of performance. If one’s goal is to develop a sustainable competitive advantage, one’s efforts must be directed not toward opportunistic deal making but rather toward the development of specific organizational competences and relationships that are difficult for competitors to match over the long term (Hayes, Wheelwright and Clark, 1988).

Competitive factors are the skills and capabilities that differentiate a firm from its competitors. As a prerequisite to any strategic planning, these competitive factors must first be identified and evaluated as to their relative importance to achieving a firm’s strategic goals. A firm can achieve a sustainable competitive advantage by utilizing its competitive factors to establish and maintain a unique operational focus.

Marketing, product innovation, manufacturing and human resource development are the key factors of the competitive advantage of a manufacturing company. Decisions in the area of manufacturing affect the entire organization, either directly or indirectly. The importance of different competitive factors can vary among industries and even nations.

Competitive strategy is a combination of the ends (goals) for which the firm is striving and means (policies) by which it is seeking to get there. Continuous technological change is often cited as a prerequisite for competitiveness and survivability of companies and whole economies.

A company's competitive strategy at a given time places particular demands on its manufacturing function and conversely that the company's manufacturing posture and operations should be specifically designed to fulfill the task demanded by strategic plans (Skinner, 1969).

Porter (1980) argues that 'understanding the industry structure must be the starting point for strategic analysis'. Strategic analysis focuses on identifying the basic, underlying characteristics of an industry, which are rooted in its economics and technology. He suggests that the collective strengths of five forces determine the state of competition and therefore the ultimate profit potential within an industry. The strategic business manager seeking to develop a competitive advantage over rival firms can use this model to better understand the industry context in which the firm operates. The five competitive forces identified by Porter are summarized in Figure 2.2.

First competitive force is the *threat of entry by new competitors*. The easier it is for new companies to enter the industry, the more cutthroat competition there will be. Factors that can limit the threat of new entrants are known as barriers to entry. Porter concludes that here are seven major sources of barriers to entry. These are: Economies of scale, product differentiation, large or risky capital requirements, switching costs occasioned by a once-for-all investment in equipment or training to accommodate any new products, a lack of access to distribution channels, cost disadvantages independent of scale and government policy.

Dealing with his central box, Porter's (1980) second competitive force is the *intensity of rivalry among existing competitors*. This describes the intensity of competition between existing firms in an industry. Highly competitive industries generally earn low returns because price competition is quite likely to leave the entire industry worse off the standpoint of profitability.

Pressure from substitute products is defined as those that 'can perform the same function as the product of the industry'. It is the likelihood that customers will switch to a competitive product or service. If the cost of switching is low, then this poses to be a serious threat.

The bargaining power of buyers is how much pressure customers can place on a business. If one customer has a large enough impact to affect a company's margins and volumes, then they hold substantial bargaining power.

The bargaining power of suppliers shows how much pressure suppliers can place on a business. The power of each important supplier or buyer group depends on a number of characteristics of its market situation and on the relative importance of its sales or purchases to the industry when compared with its overall business.

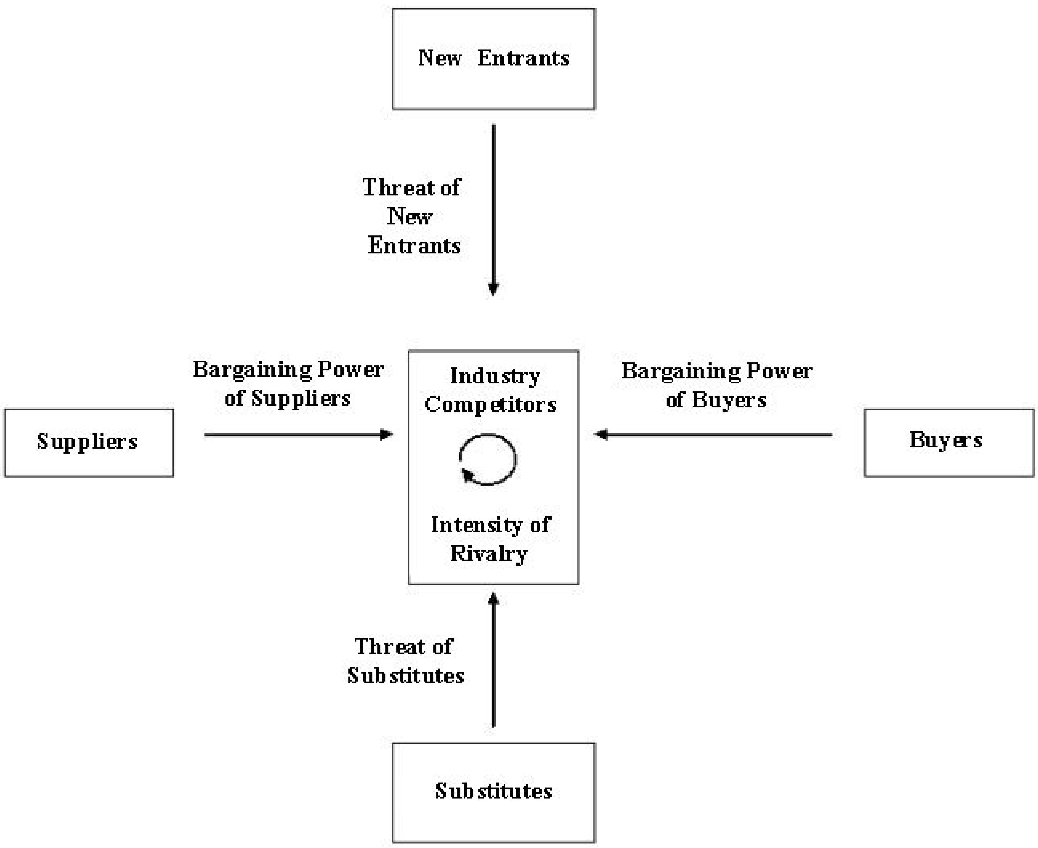


Figure 2.2. Five competitive forces *(Adopted from Porter, 1980)*

Porter (1980) also claims that operational effectiveness, although necessary to superior performance, is not sufficient, because its techniques are easy to imitate. In contrast, the essence of strategy is choosing a unique and valuable position rooted in systems of activities that are much more difficult to match.

Porter identified three generic strategies (*cost leadership*, *differentiation*, and *focus*) that can be implemented at the business unit level to create a competitive advantage. The proper generic strategy will position the firm to leverage its strengths and defend itself against the adverse effects of the five forces.

Overall Cost Leadership can be achieved by producing the same/better quality at less cost than anyone else. The firm sells its products either at average industry prices to earn a profit higher than that of rivals, or below the average industry prices to gain market share. In the event of a price war, the firm can maintain some profitability while the competition suffers losses. Even without a price war, as the industry matures and prices decline, the firms that can produce more cheaply will remain profitable for a longer period of time. The cost leadership strategy usually targets a broad market.

Differentiation implies a better/different product/service (or perceived as different) from others. A differentiation strategy calls for the development of a product or service that offers unique attributes that are valued by customers and that customers perceive to be better than or different from the products of the competition. The value added by the uniqueness of the product may allow the firm to charge a premium price for it. The firm hopes that the higher price will more than cover the extra costs incurred in offering the unique product. Because of the product's unique attributes, even if the firm's suppliers increase their prices, the firm may be able to pass along the costs to its customers who cannot find a substitute product easily.

The *focus* strategy concentrates on a narrow segment and within that segment attempts to achieve either a cost advantage or differentiation. The premise is that the needs of the group can be better serviced by focusing entirely on it. A firm using a focus strategy often enjoys a high degree of customer loyalty, and this entrenched loyalty discourages other firms from competing directly. Because of their narrow market focus, firms pursuing a focus strategy have lower volumes and therefore less bargaining power with their suppliers. However, firms pursuing a differentiation-focused strategy may be able to pass higher costs on to customers since close substitute products do not exist. Firms that succeed in a focus strategy are able to tailor a broad range of product development strengths to a relatively narrow market segment that they know very well.

The impact of five competitive forces on generic strategies is summarized in Table 2.3.

Table 2.3. Generic strategies and industry forces *(Adopted from Porter, 1980)*

Industry Force	***Generic Strategies***		
	Cost Leadership	*Differentiation*	*Focus*
Entry Barriers	Ability to cut price in retaliation discourages potential entrants.	Customer loyalty can discourage potential entrants.	Focusing develops core competencies that can act as an entry barrier.
Buyer Power	Ability to offer lower price to powerful buyers.	Large buyers have less power to negotiate because of few close alternatives.	Large buyers have less power to negotiate because of few alternatives.
Supplier Power	Better insulated from powerful suppliers.	Better able to pass on supplier price increases to customers.	Suppliers have power because of low volumes, but a differentiation-focused firm is better able to pass on supplier price increases.
Threat of Substitutes	Can use low price to defend against substitutes.	Customer's become attached to differentiating attributes, reducing threat of substitutes.	Specialized products & core competency protect against substitutes.
Rivalry	Better able to compete on price.	Brand loyalty to keep customers from rivals.	Rivals cannot meet differentiation-focused customer needs.

Ohmae (2001) puts forward his strategic triangle that shows the relationships between the customer, the corporation and the competition, each of which is a living entity. He examines strategies according these three C’s.

Customer based strategies: According to Ohmae, a corporation’s foremost concern ought to be the interest of its customers rather than that of its stockholders and other parties. Because free markets are not naturally homogenous, all customers cannot be reached with equal effectiveness. Corporation has to segment the market and direct its efforts to where they will do the most good. Segmentation can be made by objectives and by the company's market coverage capability. Segmentation by objectives is classification of customers in terms of the different ways they use the product. In segmentation by customer coverage, the company should optimize its range of market coverage, whether by channel or geographically so that its marketing costs, network servicing, adequate stocks, selling activities, transport and distributor margins are superior to those for its competitors.

Corporate based strategies: The purpose of this type of strategies is to make the most of the corporation's strengths in the functional areas that are critical to success in the industry.

Competitor based strategies: They arise out of possible sources of differentiation in functions ranging from purchasing, design and engineering to sales and servicing.

2.1.3. Manufacturing Strategy

Manufacturing is part of the strategic concept that relates a company's strengths and resources to opportunities in the market (Skinner, 1969).

For a long time, manufacturing has been considered as a technical function; the result of a series of decisions, which are merely routine, operative, and are based exclusively on obtaining maximum efficiency. Consequently, it is presupposed that manufacturing activities barely contribute to company competitiveness.

At the present time, given the dynamism and uncertainty of the competitive environment, it is necessary to give greater emphasis to production activity, recognizing its strategic nature and becoming aware of its potential contribution to business success (Avella *et al.*, 1999).

In the past, the company as a whole as being the provider of requests has perceived manufacturing's role in terms of its corporate contribution. There were two incorrect assumptions: Most of the managers thought that manufacturing is able to do everything within a given technology and manufacturing's contribution concerns the achievement of efficiency, rather than the effective support of the business needs.

It is widely accepted that a company needs a manufacturing strategy in order to give a direction to design and operation of its manufacturing systems and to make guided choices.

By definition, manufacturing strategy content refers to priorities and patterns of decisions of the manufacturing function in the pursuit of competitive advantage. Manufacturing strategy is a pattern of decisions, which determine the capability of a manufacturing system and specify how it will operate in order to meet a set of objectives which are consistent with the before specified business strategy.

TWI World Centre for Materials Joining Technology *(http://www.twi.co.uk)* gives the definition of manufacturing strategy as a set of co-ordinated objectives and action programs applied to a firm's manufacturing function and aimed at securing medium and long term, sustainable advantage over that firm's competitors. The manufacturing function requires a strategy to ensure a match, or congruence, between the company's markets and the existing and future abilities of the production system.

Operating managers in the manufacturing industry have to make choices and make decisions on a daily basis and they need some underlying strategy. If tactical decisions can be put into a strategic content and an overall policy framework, it will also help to better utilize the manufacturing resources.

In order to conduct strategic planning for manufacturing it is necessary to implement a process describing the steps to be used, employees to be involved, information to be needed and expected results to be looked for. In addition to these properties, the manufacturing strategy development process should be simple, easily understandable and have to be integrated with business strategy and corporate strategy. Manufacturing strategy should be seen not only as a plan of daily quantities of manufacturing, it should be understood as a provider of the future vision of the company.

Schroeder and Lahr (1990) list the benefits of this type of manufacturing strategy development as following:

- Helps the business to compete successfully.
- Guides tactical decision making in manufacturing.
- Helps to cope with changing environment.
- Provides a long-run view of manufacturing.
- Enhances communications with other functions.
- Puts manufacturing in a proactive role.

According to Lynch (2000) there are six basic areas of manufacturing strategy. They can be listed as following:

- Factory location and size.
- Processes.
- Production capacity.
- Manufacturing infrastructure.
- Links with other functions.

Manufacturing strategy generally addresses issues including manufacturing capacity, production facilities, use of technology, vertical integration, quality, production planning/materials control, organization and personnel.

Skinner (1969) proposed the following process of manufacturing strategy development:

- Analyze the competitive situation. How are rival companies competing in terms of product, markets, policies and channels of distribution.
- What are company's skills and resources of its present facilities and approaches?
- Formulate the company strategy: How will the company combine its strengths with market opportunities?
- Define the implications or "so-what" effects of company strategy in terms of specific manufacturing tasks.
- Study the constraints or limitations imposed by the economics and the technology of the industry.

- What are key elements that need to be controlled?
- Start the implementation.

There are some different approaches to manufacturing strategy development. Schroeder and Lahr (2000) suggest the following process, consisting of ten steps. They argued that the best implementation of this manufacturing strategy development can be carried with a team of about ten to twenty people, which consists of manufacturing head, manufacturing staff, plant managers and representatives from departments of engineering, laboratory, quality, marketing, accounting and human resources. Steps of the implementation can be listed as following:

- Business strategy summary: Includes preparing a draft of manufacturing mission statement and the manufacturing objectives.
- Determination of manufacturing mission: States a purpose for manufacturing and a priority among objectives. It is derived from the business strategy and the general situation facing manufacturing.
- Determination of manufacturing objectives: Consists of the quantitative performance measures that manufacturing must achieve. Manufacturing cost, conformance quality, inventory turnover, customer service, cycle time, time to introduce new products and time to change capacity by a stated amount are some manufacturing objectives.
- External analysis: Includes factors to be largely outside the control of the company itself. The projection of external forces should be made 5 to 10 years into the future.
- Internal analysis: It is done to determine the current strengths and weaknesses of manufacturing and those of the company, which affect manufacturing.
- Statement of competitive position: Determines better sides of manufacturing relative to their competitors for present and future periods.
- Establishment of ideal manufacturing concept: Current plans, equipment, human resources and processes have to be ignored for the purpose of doing an ideal analysis, the best or ideal way to do manufacturing at the end of planning horizon is determined.
- Determination of critical issues: Gaps or shortfalls in performance, capability and organization must be addressed to enable manufacturing organization to fulfil its mission.

- Manufacturing strategies development: Determination of how manufacturing is going to reach its objectives within the future environment. It involves correcting weaknesses and building upon strengths.
- Manufacturing programs: These are programs of the implementation of developed strategies, in other words, they link strategy and tactics.

Hayes and Wheelwright (1985) in their four-stage framework of manufacturing argue that companies should go beyond looking to align capabilities with the market. They argued that deploying policies throughout the company and developing a mission could help in achieving strategic goals. Their four-stage manufacturing strategy development process is defined as following:

- Stage 1: Minimize manufacturing's negative potential: "internally neutral".
- Stage 2: Achieve parity with competitors: "externally neutral".
- Stage 3: Provide credible support to the business strategy: "internally supportive".
- Stage 4: Pursue a manufacturing-base competitive advantage: "externally supportive".

They also stated that these stages of manufacturing strategy development are not mutually exclusive and the difficulty for a company to skip the stages. Although it seems to be possible to apply the procedure to the whole company, the real work of development occurs at the business level.

Kim and Arnold (1996) used a different concept of manufacturing strategy operationalization. Their "process model" of manufacturing strategy explores the fundamental question of how a company with particular competitive priorities decides among the various improvement programs.

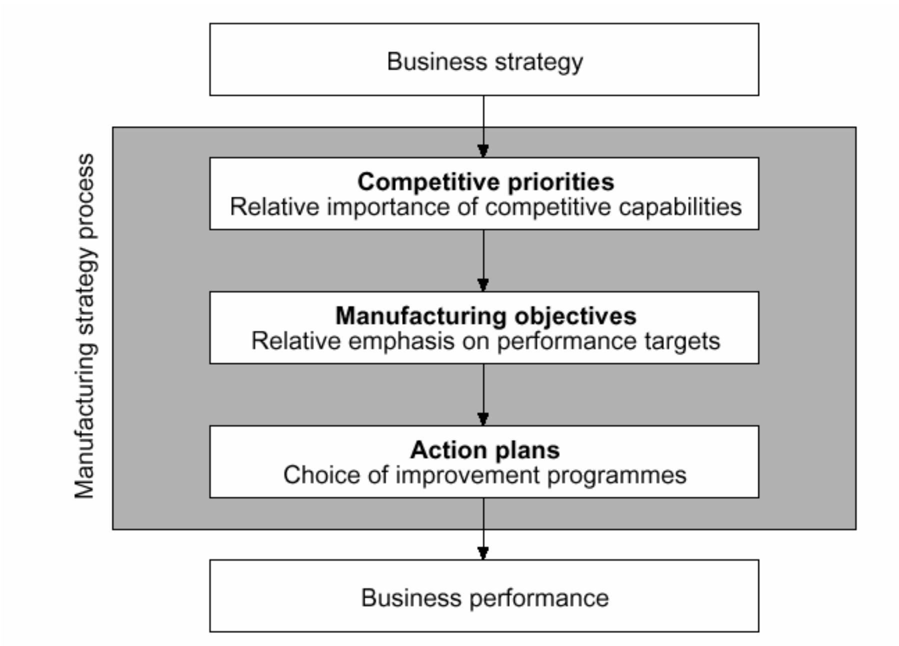


Figure 2.3. Manufacturing strategy process *(Kim and Arnold, 1996)*

As represented in Figure 2.3, they proposed a 3-step model, which links competitive priorities of a manufacturing firm with internal consistency to strategic tasks and action plans. Competitive priorities are more general aspects and action plans are the most specific and relatively easily understandable from managerial view.

Competitive priorities describe what the manufacturing function should achieve with regard to cost, quality, flexibility and delivery in order to support the business strategy effectively (Kim and Arnold, 1996).

Manufacturing objectives are defined as guidelines of strategic objectives to develop critical capabilities. Some manufacturing objectives are directly related with cost, others are more concerned about time or quality. Kim and Arnold argue that manufacturing managers have to select some of the strategic areas and the supporting manufacturing objectives and concentrate on them.

To achieve manufacturing objectives, some development programs have to be implemented. This process is called generally action plans development. Since each action program requires some resources of the company, the determination of action plans to be implemented and the allocation of resources is extremely important.

According to the authors, a company with particular competitive priorities selects particular set of manufacturing objectives consistent with those priorities. These steps are followed with selection and implementation of necessary action plans to achieve these required competitive priorities and performance targets.

2.1.4. Measurement of Competitiveness

When you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot measure it ... your knowledge is of a meager and unsatisfactory kind. (Lord Kelvin)

2.1.4.1. Performance measures

A methodological question is how to measure and to assess the competitiveness of an enterprise in an industry. Competitiveness is measured usually in financial and economical terms. For the last 20 years or more, consultants have been coaching managers to analyze their industry by:

- Delineating the scope and boundaries of the industry
- Identifying current and emerging change in and around the industry
- Projecting its evolution and future structure.

The industry is undergoing significant and largely unpredictable change: Industry boundaries are collapsing, new types of entrants are emerging, the dynamics of rivalry are shifting, and entities such as suppliers, distributors and end customers are behaving in new and unexpected ways. Most measurement systems do not provide the needed information for managers, who want to build a competitive advantage in the changing environment. Hayes and Wheelwright (1985) define two kinds of that information:

- Insight into the direction and rate of improvement in performance over time, answering such questions as “Are we getting better at the things that are most important to our manufacturing strategy?” and “What is our rate of improvement?”
- Information about results of comparison of the company’s performance against their competitors.

A measurement system must be outward looking, providing accurate information regarding how the capabilities that are key to a company’s success compare to the best in the world (Hayes, Wheelwright and Clark, 1988).

An effective measurement of a manufacturing system can be made with comparing the company’s performance with the best competitor in the market. Such an analysis must have three elements: First, the company must be objectively evaluated in terms of manufacturing capabilities and competitive advantages. Second element contains the analysis of manufacturing’s effect on overall sales, investments and profitability. Third step is benchmarking the data and finding the potential areas to improve.

3. RESEARCH METHODOLOGY

3.1. The Data

3.1.1. Survey Methodology / Survey Questions

Our research was initiated as a part of a joint project of Sabanci University, Turkish Machine Manufacturers Association (MİB), Turkish Technology Development Foundation (TTGV) and Turkish Industrialists' and Businessmen's Association (TÜSİAD) in August 2001. The first part of the research was questionnaire design. The competitive strategies and business excellence questionnaire form used in this research is obtained with a modification of the form used previously for analyzing the four different sectors from the manufacturing industry in Turkey. (Ulusoy, 2000*)* The former form was prepared in light of the *Business Excellence Model* of European Foundation for Quality Management (EFQM). *(http://www.efqm.org)* With the concern about the size of the target companies, after a series of discussions, some questions are eliminated to make the questionnaire more easily understandable and to increase the response rate.

Questionnaire form consists of 50 questions and 543 data items organized into 9 sections. Name of each chapter and number of questions and data items can be seen in the following table.

Table 3.1. Structure of the questionnaire

Chapter Name	*Number of Questions*	*Number of Data Items*
Business Profile	4	34
Structure of Competition	6	81
Manufacturing Activities	4	96
Customer Focus	1	6
Customer Relationships	9	50
Supplier Relationships	7	30
Process and Product Quality	4	29
Technology and New Product Development	7	29
Performance Data	8	188
Total	50	543

Questionnaire forms were sent to 163 member companies of Turkish Machine Manufacturers Association (MİB) at the beginning of November 2001 and a deadline for returning the filled forms was given as the end of November 2001. All questionnaires were originally addressed to the CEO of the company or to the director of manufacturing and were mostly completed and returned by a contact person holding a managerial position in the manufacturing area.

To increase the response rate, follow-up phone calls were made during December 2001 and January 2002. Total number of returned forms is 41. Thus, the rate of return is 25%.

3.1.2. Company Profiles

Four different questions are asked about companies' business profile:

Eighty one percent of the firms are working as an independent company, 17% of them are working as a subsidiary part or sister company of a bigger firm or holding company and 1 company is a strategic business unit of another company.

None of the companies have foreign partnerships.

Figure 3.1 represents a grouping of the companies in the sample according to the number of employees they employed. Almost half of the companies, 48%, have less than 100 employees; percentage of the companies with more than 350 workers is 12.

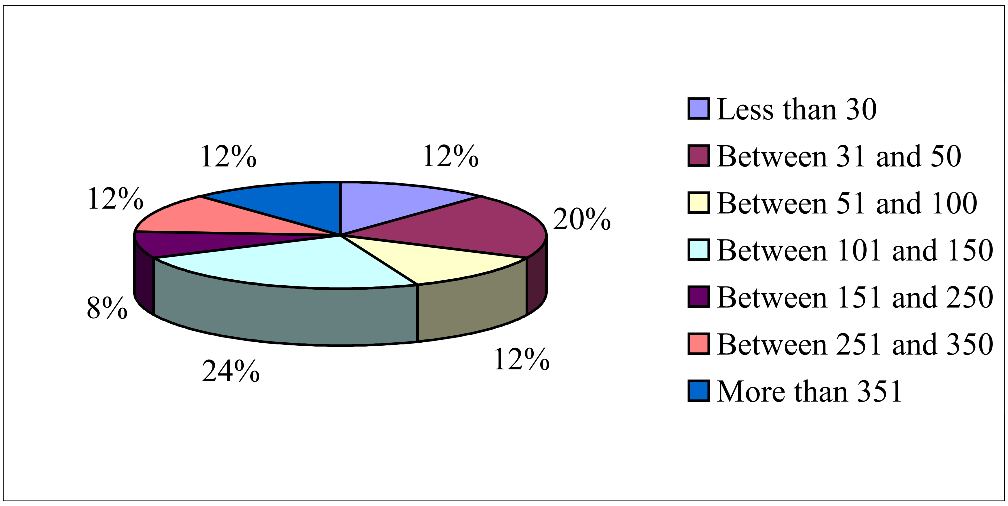


Figure 3.1. Grouping of companies according to number of employees

A grouping of the companies according to their revenues in year 2000 is give in Figure 3.2. It gives an idea about the size of the companies operating in this sector. Half of the companies have revenue less than US $ 3.200.000 in 2000. If we look at total revenue per employee per year, 36% of the companies have less than US$ 32.000. Companies having revenue per employee in the range of US$ 32.000 to 64.000 account for 32% and companies having revenue per employee more than US$ 64.000 account for 32%.

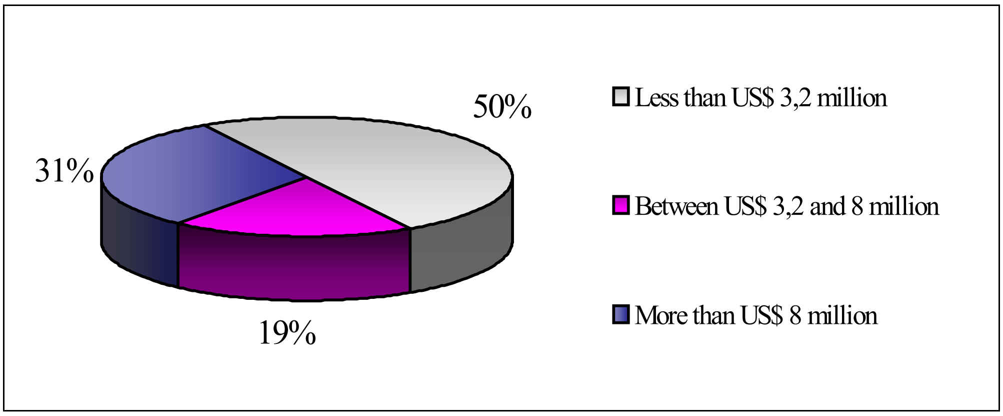


Figure 3.2. Grouping of companies according to revenues

Another question about company profiles is about the primary market for the goods produced in that company. Seventy six percent of the companies have selected Turkey as their most important market place, which is followed by 10% with Middle East and the third important marketplace for the companies is given as Germany with the rate of 5%. The other important market places can be listed as North Africa, Russia and Turkic Republics. Germany, Italy and France are the most important trade partners among the EU countries (Table 3.2).

Table 3.2. Percentage of the first 3 primary market places

Country	*1.Market Place (%)*	*2.Market Place (%)*	*3.Market Place (%)*
Turkey	76	7	5
Middle East	10	15	7
Germany	5	17	5
Italy	2	2	7
USA	2	5	0
Russia	2	2	12
North Africa	0	15	5
Turkic Republics	0	10	7
France	0	7	7
Other EU Countries	0	5	7

3.1.3. General Statistics About Data

3.1.3.1. Competitive priorities

To interpret the relative importance of the competitive priorities along the industry, the questionnaire includes a question consisting of 15 competitive priorities. The answers are given using a 5 point Likert scale, where “1” means “not important” and “5” means “extremely important”.

The ranking of competitive priorities according to their mean importance is summarized in the following table (Table 3.3).

Table 3.3. Competitive priorities: average importance and standard deviation

Competitive Priority	*Average Importance*	*Standard Deviation*
Reliable products	4,40	0,67
Consistent quality level	4,32	0,96
Customize on special products	4,18	0,91
After sales service	4,02	1,11
Dependable deliveries	4,00	0,92
Durable goods	3,95	0,95
Brand image	3,95	0,94
High performance products	3,88	1,03
Rapid deliveries	3,78	0,91
Rapid design change / new product innovation	3,60	0,93
Low price	3,51	1,10
Rapid adoption to volume changes	3,34	1,04
A broad product line	3,10	0,96
Niche market	2,82	1,39
Widespread delivery	2,79	1,26

As we see from the Table 3.3, first four important competitive priorities are all related with product. If we take the number of firms which answered a given competitive priority with “4 = very important” or “5 = extremely important” as an indicator of the given importance to that competitive priority, and list the results in Table 3.4, this claim will be more impressively visible. Table 3.5 summarizes the percentage of “1 = not important” and “2 = less important” answers.

Following three competitive priorities are about business strategies. Most of the companies have evaluated ‘customize on special products’ as an important competitive priority and consistent with this result the opposite term, ‘a broad production line’ ranked in the list of the least important priorities.

Table 3.4. Percentage of “4=very important”and“5=extremely important” answers

Competitive Priority	*Percentage of “4” and “5” Answers*
Reliable products	90,0
Consistent quality level	82,9
Customize on special products	76,9
Dependable deliveries	73,2
After sales service	73,2
Durable goods	70,7
Brand image	69,2
High performance products	68,3
Rapid deliveries	63,4
Rapid design change / New product innovation	52,5
Low price	48,8
Rapid adoption to volume changes	41,5
Niche market	34,2
A broad product line	32,5
Widespread delivery	31,6

Table 3.5. Percentage of “1 = not important” and “2 = less important” answers

Competitive Priority	*Percentage of “1” and “2” Answers*
Niche market	47,4
Widespread delivery	39,5
A broad product line	27,5
Rapid adoption to volume changes	17,1
Low price	14,6
After sales service	12,2
High performance products	9,8
Brand image	7,7
Rapid design change / New product innovation	7,5
Dependable deliveries	7,3
Customize on special products	5,1
Consistent quality level	4,9
Durable goods	4,9
Rapid deliveries	4,9
Reliable products	0,0

‘After sales service’ also appears as an important competitive priority for the sector in general. This is an expected result due to the nature of the machinery industry. The products of this sector can mostly be categorized as investment goods and thus are expected to have a relatively long useful life. Companies that provide after sales service gain a great advantage by increasing their market share. There are also enough examples, where companies earn considerable income from their after sales service activities.

Figure 3.3 gives an insight about after sales services in the German machine manufacturing industry. In comparison to other industries producing investment goods, machine manufacturers provide after sales services more in variability. These listed after sales services are: installation of the machines, training, call center, modernization and renovation of old machines, software development, financial support, leasing, scrapping, engineering and simulation services.

Figure 3.4 provides information about the total share of after sales service costs within the total revenue of German machine manufacturers in comparison to other investment goods manufacturers. Companies are grouped according to their total number of employees. It can be seen that companies employing more than 500 workers have a relatively larger share of after sales service costs in total revenue.

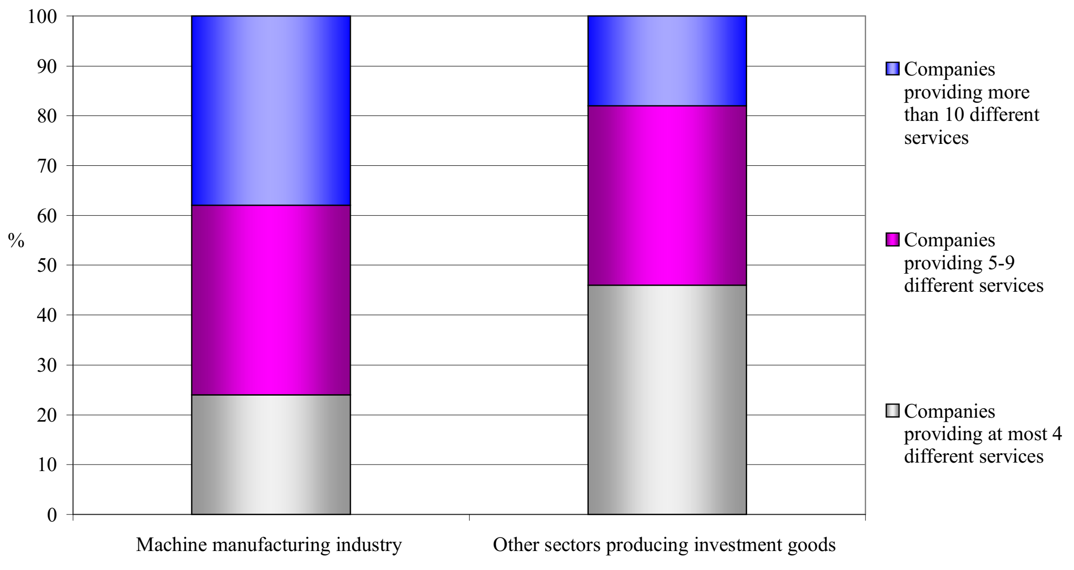


Figure 3.3. After sales services variability in German machine manufacturing industry and other investment goods sectors (IFO, 2001)

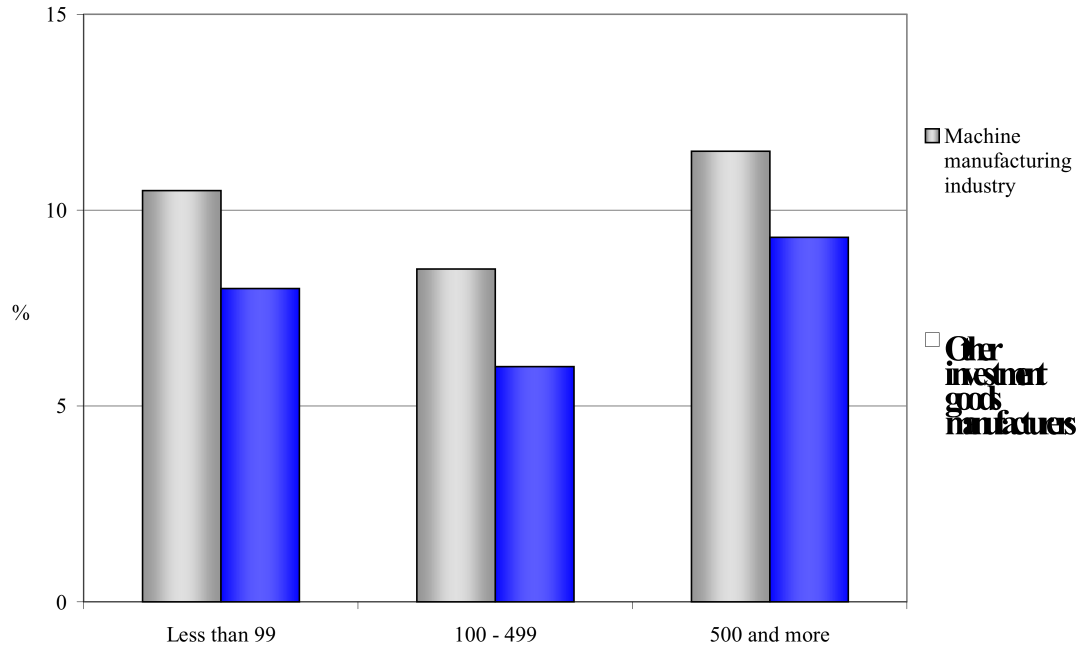


Figure 3.4. Total share of after sales service costs in total revenue for German machine manufacturing industry and other investment goods manufacturers (IFO, 2001)

‘Dependable deliveries’ is an important competitive priority that supports the first four priorities. Companies delivering their products on time and as ordered, gain advantage.

Table 3.6 gives the results from a similar study in four different sectors of Turkish manufacturing industry. The surveys are conducted in 1997 and 1998 included 82 companies from the Turkish electronics, cement, automotive sectors and part and component suppliers to the appliance industry (Ulusoy, 2000). It will be useful to compare the results obtained from different sectors with those of the machine manufacturing industry.

According to Table 3.6, the first five competitive priorities selected are ‘consistent quality level’, ‘reliable products’, ‘low price’, ‘rapid design change / new product introduction’ and ‘rapid deliveries’. It can be seen that similar to machine manufacturing industry, competitive priorities like ‘reliable products’ and ‘consistent quality level’ are valid in general over all sectors.

Table 3.6. Competitive priorities for the next two years - in four different sectors
(Ulusoy, 2000)

INDUSTRIAL SECTOR							
Appliances P&C Suppliers	***Automotive***	***Electronics***				***Cement***	
		Components	*P&I Equipment*	*Telecom*	*Consumer*	*Large*	*Small*
Consistent quality level	Reliable products	Consistent quality level	Consistent quality level	Rapid design changes	Consistent quality level	Consistent quality level	Consistent quality level
Low price	Consistent quality level	Reliable products	Reliable products	High performance products	Low price	Reliable products	Reliable products
Rapid deliveries	After sales service	Rapid design changes	After sales service	Low price	After sales service	Low price	Dependable deliveries
Dependable deliveries	Rapid design changes	Customize on special products	Low price	Consistent quality level	Reliable products	Dependable deliveries	Low price
Reliable products	Low price	Rapid deliveries	Rapid design changes	Customize on special products	Rapid design changes	Brand image	Rapid deliveries

The main difference of machine manufacturing industry from the other four sectors occurs in the competitive priority ‘low price’. Other sectors put price-based competition among the most important priorities, which is not the case for machine manufacturers. It can be stated that machine manufacturing industry’s competitive strategy is based on product differentiation rather than low price.

A study in EU countries shown in Table 3.7 states the estimates for the response times of the rivals for different competitive strategies (IPTS and ECJRC, 1999). Since the response time of competitors for ‘low price’ is short, the strategy of machine manufacturing industry seems appropriate in terms of competitiveness.

Table 3.7. Response time of competitors to different competitive strategies *(IPTS and ECJRC, 1999)*

Factor	***Response time of competitors***
Low price	2 months
Advertising	1 year
New product	2 years
New product development process	3 years
Distribution network	4 years
Human resources	7 years

3.1.3.2. Manufacturing objectives

The survey includes a question about companies’ manufacturing objectives for the next two years. The evaluation of given 16 manufacturing objectives is made using a 5 point Likert scale, where “1” means “not important” and “5” indicates the extreme importance. The average importance scores of the given manufacturing objectives are presented in the Table 3.8. As we can see, the most important performance measures are ‘increasing market share’, ‘decreasing unit costs’, ‘increasing direct labor productivity’ and ‘increasing conformance quality’. The answers reflect the current status of the Turkish machine manufacturing industry perfectly. It shows that companies are somewhat aware of their defective sides and it is this awareness, which might lead to the initiation of industry wide improvement programs. Table 3.9 supports this claim by showing number of firms that see the given manufacturing objectives in the most important 3 objectives.

Table 3.8. Ranking of manufacturing objectives

Manufacturing Objective	*Mean Importance*	*Standard Deviation*
Increase market share	4,59	0,77
Increase direct labor productivity	4,29	0,68
Decrease unit cost	4,20	0,84
Increase conformance quality	4,20	0,81
Increase production rate	4,07	0,75
Reduce production lead time	3,85	0,82
Producing high value added products	3,85	0,96
Reduce break-even points	3,85	0,92
Reduce production flow time	3,76	0,94
Increase delivery reliability	3,66	0,82
Decrease breakdowns and not planned stops	3,56	0,92
Reduce set-up / changeover times	3,49	0,90
Decrease new product development time	3,41	0,89
Decrease new product introduction time	3,27	0,92
Increase end products stock turnover rate	3,15	0,96
Increase input materials stock turnover rate	3,10	1,00

Table 3.9. Number of firms showing a manufacturing objective among the most important 3 manufacturing objectives

Manufacturing Objective	*Number of Firms*
Decrease unit cost	21
Increase market share	19
Increase conformance quality	14
Increase direct labor productivity	9
Producing high value added products	6
Increase production rate	5
Reduce production flow time	3
Decrease new product development time	3
Reduce break-even points	2
Reduce production lead time	2
Increase input materials stock turnover rate	2
Decrease new product introduction time	1
Increase delivery reliability	1
Decrease breakdowns and not planned stops	1
Reduce set-up / changeover times	0
Increase end products stock turnover rate	0

Table 3.10. Percentage of “4=very important”and“5=extremely important” answers

Manufacturing Objective	*Percentage of “4” and “5” Answers*
Increase direct labor productivity	92,7
Increase market share	92,7
Increase conformance quality	80,5
Decrease unit cost	78,1
Increase production rate	75,6
Reduce production lead time	68,3
Producing high value added products	65,9
Reduce break-even points	60,0
Increase delivery reliability	58,5
Reduce production flow time	56,1
Decrease breakdowns and not planned stops	53,7
Decrease new product development time	48,8
Reduce set-up / changeover times	46,3
Decrease new product introduction time	41,5
Increase end products stock turnover rate	34,2
Increase input materials stock turnover rate	29,3

Table 3.11. Percentage of “1 = not important” and “2 = less important” answers

Manufacturing Objective	*Percentage of “1” and “2” Answers*
Increase input materials stock turnover rate	31,7
Increase end products stock turnover rate	29,3
Decrease new product introduction time	19,5
Decrease new product development time	17,1
Reduce set-up / changeover times	12,2
Producing high value added products	9,8
Decrease breakdowns and not planned stops	9,8
Reduce production flow time	7,3
Increase delivery reliability	7,3
Reduce break-even points	5,0
Reduce production lead time	4,9
Increase market share	4,9
Decrease unit cost	2,4
Increase conformance quality	2,4
Increase direct labor productivity	2,4
Increase production rate	0,0

According to the resulting percentage of 4 and 5 answers, the first two manufacturing objectives differentiate clearly from other objectives. It can be stated that all of the most important manufacturing objectives are related to three main components of unit cost.

Table 3.12 gives data about the composition of manufacturing cost over the period 1998-2000 for the companies that have participated in this survey. As expected, the most important cost item is cost of materials. Direct labor cost follows it with an average value of 20%. An interesting point is the stability of distribution of manufacturing cost for different years.

Increasing market share gives companies the opportunity to use the advantage of economies of scale; in other words, increasing market share is expected to lead the companies to strengthen their competitive advantage. It will also give them the opportunity to use their bargaining power and buy materials or services from their suppliers at lower costs. So, the most important item of their cost, material cost can be decreased. 'Increasing direct labor productivity' is the main issue of productivity and 'increasing conformance quality' is the reflection of the given importance to quality improvement. These 3 items together are the main components of 'decreasing unit cost', which is also in the list of the first 5 important manufacturing objectives.

Table 3.12. The distribution of manufacturing costs

Manufacturing cost component	***1998***	***1999***	***2000***
		(%)	
Direct labor cost	21	20	20
Indirect labor cost	8	10	7
Direct material cost	45	43	45
Indirect material cost	11	11	10
Overhead costs	17	17	17

In comparison of manufacturing cost with other industries in Table 3.13, it is clear that machine manufacturing industry has higher labor costs (Ulusoy*,* 2000). It may be because of the low values for material costs in machine manufacturing industry, or because of the need for skilled workers for this sector.

Table 3.13. Comparison of manufacturing cost distribution among different sectors *(Ulusoy, 2000)*

Industrial sector	***Material costs (%)***	***Labor costs (%)***	***Overhead costs (%)***
Components	60	25	15
P&I Equipment	56	24	20
Telecommunications	74	16	11
Consumer electronics	72	10	18
Automotive	87	5	8
Appliances p&c suppliers	61	18	21

Also the manufacturing objective of ‘increase production rate’ is mainly related to the objectives of ‘increase direct labor productivity’, ‘decrease unit cost’ and ‘increase market share’.

‘Increase input materials stock turnover rate’ and ‘increase end products stock turnover rate’ are the least important two manufacturing objectives. It is an expected result of the current status of machine manufacturing industry. Companies in this sector are working generally project based on demand, so they have no such a problem according to warehouse management.

Table 3.14 summarizes a similar study investigating the manufacturing strategies adopted by four different sectors of Turkish manufacturing industry (Ulusoy, 2000). Electronics, cement, automotive and appliances for parts and components sectors have evaluated ‘decrease unit cost’ as the most important manufacturing objective in general. This is a reflection of competitive priority ‘low price’, which has been evaluated as important for these sectors.

‘Increase market share’, ‘increase conformance quality’, ‘decrease new product development time’ and ‘increase production rate’ are other important manufacturing objectives. These manufacturing objectives also support the competitive priorities of the listed sectors.

Table 3.14. Manufacturing objectives for the next two years – in four different sectors *(Ulusoy, 2000)*

INDUSTRIAL SECTOR							
Appliances P&C Suppliers	***Automotive***	***Electronics***				***Cement***	
		Components	*P&I Equipment*	*Telecom*	*Consumer*	*Large*	*Small*
Decrease unit cost	Increase conformance quality	Decrease unit cost	Increase market share	Decrease unit cost	Decrease unit cost	Decrease unit cost	Decrease unit cost
Increase market share	Decrease unit cost	Increase conformance quality	Decrease unit cost	Decrease new product development time	Decrease new product development time	Increase market share	Increase market share
Increase conformance quality	Increase market share	Increase market share	Increase conformance quality	Increase market share	Increase profitability	Decrease breakdowns and stops	Decrease breakdowns and stops
Increase profitability	Decrease new product development time	Increase production rate	Decrease new product development time	Increase delivery rate	Increase conformance quality	Increase profitability	Increase conformance quality
Increase production rate	Increase direct labour productivity	Increase delivery reliability	Increase production rate	Increase conformance quality	Increase market share	Increase conformance quality	Increase production rate

It is expected to have different priorities and manufacturing objectives for countries in various stages of development. Nagabhushana and Shah (1999) summarize in Table 3.15 the top three manufacturing objectives from different countries / regions. The authors have taken the priorities for Europe, Japan, USA, Korea and Mexico from a 1990 survey published in *Benchmarking Global Manufacturing* (Miller *et al.,* 1992). In their investigation of manufacturing priorities and action plans of Indian industries, Nagabhushana and Shah (1999) propose that as a company moves up on the development ladder, cost is likely to become a qualifier criterion, while quality and delivery tend to become order winning criteria.

Table 3.15. Comparison of manufacturing objectives for different countries / regions *(Nagabhushana and Shah, 1999)*

	1	2	3
Europe	Reduce rejection/ rework rate	Increase delivery reliability	Improve performance of the products
Japan	Increase delivery reliability rate	Improve ability to change product design to customer needs	Reduce rejection / rework rate
USA	Reduce rejection / rework rate	Increase delivery reliability rate	Improve performance of the products
Korea	Improve performance of the products	Reduce rejection / rework rate	Increase delivery speed
India	Reduce unit cost	Improve performance of the products	Increase delivery speed
Mexico	Reduce unit rate	Increase delivery speed	

By looking at the picture of manufacturing priorities in different countries given in Table 3.15, it can be seen that delivery speed and delivery reliability are in the list of the most important 3 manufacturing objectives for all countries, but we cannot see it in the list of most important 5 manufacturing objectives for the machine manufacturing industry in Turkey.

‘Increase market share’ is the most important manufacturing objective in Turkey, which can be interpreted as following. Manufacturing industries in Europe, Japan and Korea are bigger and powerful than Turkish machine manufacturing industry, so their first objectives are all related with improvement, either improvement of quality of product and manufacturing, or improvement of delivery systems. In contrast, Turkish machine manufacturing industry is a growing sector and their first objective is increasing market share, which is supported with the manufacturing objectives ‘decrease unit cost’ and ‘increase conformance quality’. This result is not surprising, in the sense that the sector consists of many small enterprises which want to gain market share from domestic and international rivals.

3.1.3.3. Action plans

In the questionnaire it is also asked about action plans that each manufacturer intends to emphasize among the past two years. A given list of 35 action plans is evaluated by manufacturers using a 6 point scale, where “1 = negative emphasis” and “5 = important emphasis”. “0” indicates that this action plan was not present or was not put into practice in that company. The mean emphasis of each action plan and percentage of firms that selected the particular action plan is given in Table 3.16, in order of mean emphasis. Table 3.17 summarizes the answers according to the percentage of given answers.

After examining the first 5 action plans employed in the past two years, it seems consistent with the competitive priorities discussed earlier and the manufacturing objectives. Consistent with the structure of the industry, ‘aligning customer needs and new product development’ is evaluated with great emphasis. Companies in this sector are manufacturing on order of their customers, and customer needs gain more importance. ‘Computer aided design (CAD)’ supports this action plan.

Table 3.16. Action plans employed within the past 2 years

Action Plans	*Percentage of Firms*	*Mean Emphasis*
Computer aided design (CAD)	85,0	4,18
Total Quality Management program	75,6	4,06
Aligning customer needs and product development	85,4	3,89
Improving after sales service	82,5	3,88
JIT production	80,5	3,82
Quality certificates for products	65,9	3,74
Reducing setup / changeover times	63,4	3,73
JIT procurement	80,5	3,70
Zero defect	55,0	3,68
Integration of information systems of functions	70,7	3,66
Quality certificates for processes and management	73,2	3,63
Improvement of supplier relationships	78,1	3,59
Restructuring	68,3	3,57
Developing new processes for new products	75,6	3,48
Green production technologies	56,1	3,48
Production automation	58,5	3,46
Employee empowerment	70,7	3,45
Activity based costing (ABC)	56,1	3,43
Training of managers	65,9	3,41
Linking manufacturing strategy to business strategy	58,5	3,38
Training of employees (Excluding managers)	80,5	3,36
Improvement of QC lab facilities	61,0	3,36
Warehouse management	78,1	3,34
Manufacturing resource planning (ERP, MRPII)	53,7	3,32
Quality certificates for environment protection	46,3	3,32
Quality circles / Quality improvement teams	56,1	3,30
Preventive maintenance	73,2	3,30
Value engineering / Redesign of products	65,9	3,30
Energy saving	70,0	3,29
Cross-functional teams	58,5	3,21
Statistical process control	56,1	3,17
Developing new processes for existing products	80,0	3,13
Conformance to environmental standards	53,7	3,05
Using internet in supply chain	51,2	2,95
Automation of production and inventory control systems	51,2	2,95

Table 3.17. Percentage of answers for action plans employed within the past 2 years

Action Plans	*Percentage of 1 and 2 Answers*	*Percentage of 4and 5 Answers*
Computer aided design (CAD)	2,9	88,2
Total Quality Management program	0,0	80,7
Aligning customer needs and product development	2,9	71,4
Restructuring	14,3	67,9
JIT procurement	6,1	66,7
Improving after sales service	3,0	66,7
JIT production	0,0	66,7
Integration of information systems of functions	6,9	65,5
Production automation	20,8	62,5
Improvement of supplier relationships	9,4	59,4
Quality certificates for products	7,4	59,3
Quality certificates for processes and management	6,7	56,7
Developing new processes for new products	9,7	54,8
Manufacturing resource planning (ERP, MRP II)	22,7	54,6
Zero defect	9,1	54,6
Reducing setup / changeover times	3,9	53,9
Green production technologies	17,4	52,2
Linking manufacturing strategy to business strategy	12,5	50,0
Quality circles / Quality improvement teams	21,7	47,8
Activity based costing (ABC)	13,0	47,8
Cross-functional teams	29,2	45,8
Employee empowerment	13,8	44,8
Training of managers	7,4	44,4
Energy saving	21,4	42,9
Training of employees (Excluding managers)	12,1	42,4
Quality certificates for environment protection	26,3	42,1
Value engineering / Redesign of products	14,8	40,7
Warehouse management	12,5	40,6
Improvement of QC lab facilities	16,0	40,0
Developing new processes for existing products	21,9	37,5
Conformance to environmental standards	36,4	36,4
Automation of production and inventory control systems	38,1	33,3
Preventive maintenance	10,0	30,0
Using internet in supply chain	33,3	28,6
Statistical process control	17,4	21,7

‘Total quality management (TQM)’ is ranked as the second best action plan in the list of most used and the most beneficial action plans. This action plan is directly related with the competitive priority ‘consistent quality level’ and the manufacturing objective ‘improving conformance quality’.

Companies in this sector consider ‘after sales service’ as an important competitive priority, they supported this with evaluating the action plan ‘improving after sales services’ among the most used 5 action plans.

An interesting point is that ‘training of employees excluding managers’, ‘developing new processes for existing products’, ‘developing new processes for new products’ and ‘warehouse management’ that appear in the list of most applied action plans according to percentage of the companies in Table 3.16 are not evaluated with great emphasis. It makes us to think that these action plans are applied in the past two years without getting much benefit.

The second part of the question asked companies about their plans to apply action plans for the next two years. They selected from the same list of 35 action plans the most important 7 plans for them for their operations in the next two years and ranked them from “1” to “7”.

The list of action plans for the next two years and their average ranking are given in Table 3.18. In order to allow pairwise comparison, action plans are listed in the same order as in Table 3.16.

‘Total Quality Management’ appears to be the top in the list of the action plans to be implemented in the next two years. The same result is also reported in Table 3.19, which shows the percentage of the companies that included the given action plans among the most important action plans for the next two years. About one third of the companies plan to implement ‘TQM’ in the next two years.

Table 3.18. Action plans for the next 2 years

Action Plans	*Percentage of Firms*	*Mean Emphasis*
Computer aided design (CAD)	24,4	3,50
Total Quality Management program	46,3	2,47
Aligning customer needs and product development	39,0	3,56
Improving after sales service	41,5	5,59
JIT production	41,5	3,71
Quality certificates for products	22,0	4,00
Reducing setup / changeover times	14,6	5,67
JIT procurement	22,0	3,11
Zero defect	24,4	3,60
Integration of information systems of functions	19,5	3,63
Quality certificates for processes and management	7,3	1,67
Improvement of supplier relationships	7,3	5,67
Restructuring	26,8	2,73
Developing new processes for new products	26,8	3,27
Green production technologies	7,3	3,00
Production automation	24,4	3,90
Employee empowerment	19,5	3,13
Activity based costing (ABC)	29,3	4,50
Training of managers	34,2	4,57
Linking manufacturing strategy to business strategy	26,8	2,64
Training of employees (Excluding managers)	31,7	5,54
Improvement of QC lab facilities	22,0	3,78
Warehouse management	9,8	6,50
Manufacturing resource planning (ERP, MRP II)	12,2	4,20
Quality certificates for environment protection	2,4	0,00
Quality circles / Quality improvement teams	24,4	3,90
Preventive maintenance	7,3	5,67
Value engineering / Redesign of products	4,9	2,00
Energy saving	17,1	4,57
Cross-functional teams	7,3	5,00
Statistical process control	14,6	4,67
Developing new processes for existing products	17,1	3,57
Conformance to environmental standards	9,8	6,00
Using internet in supply chain	4,9	4,50
Automation of production and inventory control systems	4,9	5,50

Table 3.19. Percentage of firms which include the given action plans among the most important 3 action plans for next two years

Action Plans	*Percentage of Firms*
Total Quality Management program	36,6
JIT production	22,0
Restructuring	22,0
Aligning customer needs and product development	22,0
Linking manufacturing strategy to business strategy	19,5
Developing new processes for new products	14,6
JIT procurement	12,2
Employee empowerment	12,2
Quality circles / Quality improvement teams	12,2
Improvement of QC lab facilities	12,2
Integration of information systems of functions	9,8
Developing new processes for existing products	9,8
Training of managers	9,8
Production automation	9,8
Computer aided design (CAD)	9,8
Zero defect	9,8
Quality certificates for products	9,8
Activity based costing (ABC)	7,3
Quality certificates for processes and management	7,3
Statistical process control	4,9
Value engineering / Redesign of products	4,9
Manufacturing resource planning (ERP, MRP II)	4,9
Energy saving	4,9
Improving after sales service	4,9
Cross-functional teams	2,4
Training of employees (Excluding managers)	2,4
Improvement of supplier relationships	2,4
Green production technologies	2,4
Reducing setup / changeover times	2,4
Using internet in supply chain	0,0
Conformance to environmental standards	0,0
Preventive maintenance	0,0
Quality certificates for environment protection	0,0
Automation of production and inventory control systems	0,0
Warehouse management	0,0

Comparison of action plans in different countries and regions is given in Table 3.20 (Nagabhushana and Shah, 1999). The results for Europe, Japan, USA, Korea and Mexico are reproduced from a survey published in *Benchmarking Global Manufacturing (*Miller *et al., 1992).*

The comparison of action plans among different countries shows the same picture as the comparison of manufacturing objectives. Turkish machine manufacturing industry has different action plans than the manufacturing industries of the countries / regions reported in Table 3.20. It results from the nature of the industry. This sector consists of young and growing enterprises, which want to increase their market share by producing higher quality products aligned with customers. 'CAD', 'aligning customer needs and product development' are related with this purpose. 'Improving after sales service' supports this purpose strongly.

Table 3.20 also shows how different countries with different manufacturing objectives have translated their priorities into action plans. There is a strong linkage between manufacturing objectives and action plans for most of the countries in the list.

In the case of Turkish machine manufacturing industry, we observe a certain consistency between manufacturing objectives and the action plans applied in the past two years. The most important manufacturing objective for this industry is 'increase market share', which is rated with a mean importance of 4,59. If we look at the action plans; 'computer aided design', 'aligning customer needs to product development', 'improving after sales services' are in the list of the most highly rated action plans, which all help companies to increase their market share.

'Increasing conformance quality', the third important manufacturing objective of machine manufacturing industry is also supported with right action plans such as 'computer aided design', 'total quality management' and 'quality certificates for products', which are in the list of five important action plans.

Table 3.20. Comparison of action plans of different countries / regions

(Nagabhushana and Shah, 1999)

	1	*2*	*3*	*4*	*5*
Europe	Linking manufacturing and business strategies	Integrating information systems in manufacturing	Quality function deployment	Supervisor training for old products	Worker training systems across functions
Japan	Integrating information systems in manufacturing	Developing new processes for new products	Investing in improved production inventory control systems	Developing new processes training	Integrating information work teams
USA	Linking manufacturing and business strategies	Job enlargement and enrichment	Statistical quality control	Worker and supervisor plants	Inter functional
Korea	Quality function deployment	Supervisor training	Management training	Recondition-physical	Worker training of tasks and responsibility
India	ISO 9000 certification	Worker training	Total quality management	Periodic review / action programs for follow-up	Integrating information systems in manufacturing
Mexico	Linking manufacturing and business strategies	Worker, supervisor training	Statistical quality control	Management training	Giving workers broader range

Table 3.21. Action plans for the next two years – in four sectors *(Ulusoy, 2000)*

INDUSTRIAL SECTOR							
Appliances P&C Suppliers	***Automotive***	***Electronics***				***Cement***	
		Components	*P&I Equipment*	*Telecom*	*Consumer*	*Large*	*Small*
Total quality management	JIT production	Improvement of QC lab facilities	Total quality management	Total quality management	JIT procurement	Energy saving	Conformance to environmental standards
Employee empowerment	Aligning customer needs with product development	Production automation	Production automation	Developing new processes for new pr.	Restructuring	Preventive maintenance	Energy saving
Zero defect	Quality certificates for environmental protection	Total quality management	Quality certificates for products	Aligning customer needs with product development	JIT production	Total quality management	Production automation
Restructuring	Integration of manufacturing systems	JIT production	Developing new processes for new products	Activity based costing	Quality certificates for products	IT productions	Training of managers
Quality improvement teams	Improvement of facility layout	Activity based costing	Quality certificates for process&management	Restructuring	Zero defect	Restructuring	Preventive maintenance
Statistical process control	Restructuring	Employee empowerment	Aligning customer needs with product development	Statistical process control	Quality certificates for process&management	Employee empowerment	Improvement of QC lab facilities
Developing new processes for new products	Improvement of supplier relations	Automation of production & inventory control systems	Employee empowerment	Training of employees (excluding managers)	Total quality management	Quality improvement teams	Quality improvement teams
	Zero defect	Zero defect				Training of managers	JIT productions

An interesting comparison of the machine manufacturing industry can be achieved by comparing the sector with other four sectors of Turkish industry. Table 3.21 gives the results of this study for electronics, cement, automotive and appliances parts and components suppliers sectors (Ulusoy, 2000).

The most important action plans of these four different sectors can be grouped in the general areas of quality, production and organization. With great emphasis evaluated action plans are, ‘total quality management’, ‘restructuring’, ‘JIT production’, ‘production automation’, ‘employee empowerment’, ‘zero defect’ and ‘aligning customer needs and product development’. This list of action plans shows a great similarity with the list of action plans employed in the machine manufacturing sector.

As in machine manufacturing industry, ‘TQM’ is the most employed action plan in these sectors. It is a broad program, which has to be implemented concurrently with some other quality programs. ‘Quality certificates for products’ and ‘quality improvement teams’ are other action plans applied in these industries.

3.2. Summary

In this chapter, general statistics about survey results are given and some interpretations about the current status of Turkish machine manufacturing industry are made. Company profiles are given first and competitive strategies applied in this sector are evaluated according to the responses of the companies to 4 questions: importance of the given 15 competitive priorities for the next two years, importance of the given 16 manufacturing objectives for the next two years, relative emphasis of the action plans applied in the past two years and ranking of the action plans according to their emphasis for the next two years.

To help to determine the competitive strategies used in this sector more effectively, a more advanced and detailed statistical analysis is made. Results of these analyses are summarized in the following chapters.

4. FACTOR ANALYSIS

The aim of this chapter is to group the questions of the questionnaire according to their shared variance. Three questions, importance of given competitive priorities, importance of given manufacturing objectives and emphasis of given action plans for the past two years are selected according to the procedure suggested by Kim and Arnold (1996). The target is to group 15 competitive priorities, 16 manufacturing objectives and 35 action plans in order to explain the same characteristic with smaller number of variables.

First section of the chapter gives a brief explanation of factor analysis; method used in this thesis is explained in the second section, which is followed by results and discussion.

4.1. Introduction to Factor Analysis

Factor analysis is a generic name given to a class of multivariate statistical methods whose primary purpose is data reduction and summarization (Hair *et al.*, 1998).

Factor analysis is used to uncover the dimensions of a set of variables. The purpose is to describe, if possible, the covariance relationships among many variables in terms of a few underlying, but unobservable, random quantities called factors. It reduces attribute space from a larger number of variables to a smaller number of factors.

In other words, if data contains many variables, you can use factor analysis to reduce the number of variables and group variables with similar characteristics together. For example, a hypothetical survey questionnaire may consist of 100 questions, but since not all of the questions are identical, they do not all measure the basic underlying dimensions to the same extent. By using factor analysis, the analyst can identify the separate dimensions being measured by the survey and determine a factor loading for each variable on each factor (Statistica, 2002).

Factor analysis can be considered as an extension of principal component analysis. The basic idea is still that it may be possible to describe a set of p variables X_1 , X_2 , X_3 , ….. , X_p in terms of a smaller number of indices or factors and hence elucidate the relationship between these variables. Both can be viewed as attempts to approximate the covariance matrix **C**. There is however, one important difference: principal components analysis is not based on any particular statistical model, but factor analysis is based on a rather special model.

Unlike some other statistical methods, in which one or more variables are explicitly considered as the criterion or dependent variable and all others the predictor or independent variables; factor analysis is an interdependence technique in which all variables are simultaneously considered. Each of the observed (original) variables is considered as a dependent variable that is a function of some underlying, latent and hypothetical set of factors (Hair *et al.,* 1998).

4.1.1. General Purposes of Factor Analysis

With factor analysis, the researcher can first identify the separate dimensions of the structure and then determine the extent to which each variable is explained by each dimension. Once these dimensions and the explanation of each variable are determined, the two primary uses for factor analysis – summarization and data reduction - can be achieved.

Factor analysis could also be used for any of the following purposes (*http://www2.chass.ncsu.edu/garson/pa765/factor.htm*):

- To select a subset of variables from a larger set based on which original variables have the highest correlations with the principal component factors.
- To create a set of factors to be treated as uncorrelated variables as one approach to handling multicollinearity in such procedures as multiple regression.
- To validate a scale or index by demonstrating that its constituent items load on the same factor and to drop proposed scale items which cross-load on more than one factor.
- To establish that multiple tests measure the same factor, thereby giving justification for administering fewer tests.
- To identify clusters of cases and/or outliers.
- To determine network groups by determining which sets of people cluster together.

4.1.2. Types of Factor Analysis

Exploratory factor analysis (EFA) seeks to uncover the underlying structure of a relatively large set of variables (*http://www2.chass.ncsu.edu/garson/pa765/factor.htm).* The researchers assumption is that any indicator may be associated with any factor. This is the most common form of factor analysis. There is no prior theory and one uses factor loadings to intuit the factor structure of the data.

Confirmatory factor analysis (CFA) seeks to determine if the number of factors and the loadings of measured variables on them conform to what is expected on the basis of pre-established theory (*http://www2.chass.ncsu.edu/garson/pa765/factor.htm).* Indicator variables are selected on the basis of prior theory and factor analysis is used to see if they load as predicted on the expected number of factors. The researchers assumption is that each factor is associated with a specified subset of indicator variables.

The most common type of factor analysis is referred to as *R factor analysis*. The factor analysis is applied to a correlation matrix of variables and it analyses a set of variables to identify the dimensions that are not easily observed. In this mode, rows are cases, columns are variables and cell entities are scores of the cases on variables.

Factor analysis also may be applied to a correlation matrix of the individual respondents based on their characteristics. This is referred to as *Q factor analysis*, which seeks to cluster the cases rather than the variables. This type of factor analysis is not utilized very frequently because of computational difficulties. Instead, most researchers utilize some type of cluster analysis to group individual respondents.
There are also some other types of factor analysis, which are rarely applied.
O-mode factor analysis, T-mode factor analysis and S-mode factor analysis.

4.1.3. Before Executing Factor Analysis

Data reduction and summarization can be performed either with pre-existing sets of variables or with variables created with new research.

The design of a factor analysis involves three basic decisions (Hair *et al.,* 1998):

- Selection and processing of the input data resulting in the correlation matrix.
- The design study in terms of number of variables, measurement properties of variables and the types of allowable variables.
- The sample size.

Before starting the analysis the researcher must ensure that the data matrix has sufficient correlations to justify the application of factor analysis. If all correlations are less than 0,30, then factor analysis is probably inappropriate (Hair *et al.,* 1998).

SPSS provides the *anti-image correlation matrix*, which is just the negative value of the partial correlation. Relatively large partial correlation or anti-image correlation matrix shows that the data is not suitable for factor analysis.

Another test used for determining the appropriateness of factor analysis is the *Barlett test of sphericity*. It examines the whole correlation matrix and provides a statistical probability that the correlation matrix has significant correlations among at least some of the variables. It tests the null hypothesis that the variables are uncorrelated. A large B value means that the null hypothesis can be rejected. Increasing the sample size allows to detect the correlations more sensitively (Hair *et al.,* 1998).

Kaiser-Meyer-Olkin (KMO) Measure of sampling adequacy can also be used to measure the degree of intercorrelations among the variables. This index ranges from 0 to 1, reaching 1 when each variable is perfectly predicted without error by the other variables. A small KMO value means that the correlations are not large enough to be explained by underlying factors. A KMO value greater than 0,5 is large enough to explain the correlations by underlying factors.

4.1.4. Procedure for a Factor Analysis

Two basic models can be used to obtain factor solutions, which are named as common factor analysis and principal component analysis.

Principal component analysis considers the total variance and derives factors that contain small proportions of unique variance, and in some instances, error variance. By common factor analysis, an estimate of the shared or common variance among the variables is used. Both methods are widely used. The principal component model is appropriate when the primary concern is about prediction of the minimum number of factors needed to account for the maximum portion of variance represented in the original set of variables.

There are three stages to a factor analysis. To begin with, provisional factor loadings a_{ij} should be determined. One way to do this is to do principal components analysis and neglect all of the principal components after the first m, which are themselves taken to be the m factors. Another approach is Maximum Likelihood Factor Analysis, which can be used if the researcher can make the assumption that the raw data arise from a multivariate normal distribution.

The observable random vector **X,** with p components has mean μ and covariance matrix **C**. The factor model postulates that **X** is linearly dependent upon a few unobservable random variables $F_1, F_2, \ldots, F_m$ called *common factors*, and p additional sources of variation $\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_p$ called *errors* or sometimes specific factors (Johnson and Wichern, 1998).

$$X_1 - \mu_1 = a_{11} F_1 + a_{12} F_2 + \ldots + a_{1m} F_m + \varepsilon_1$$

$$X_2 - \mu_2 = a_{21} F_1 + a_{22} F_2 + \ldots + a_{2m} F_m + \varepsilon_2$$

....

$$X_p - \mu_p = a_{p1} F_1 + a_{p2} F_2 + \ldots + a_{pm} F_m + \varepsilon_p$$

The coefficient a_{ij} is called the loading of the *i*th variable on the *j*th factor, the matrix **A** is the matrix of factor loadings.

The *i*th specific factor ε_i is associated only with the *i*th response. The p deviations are expressed in terms of p+m random variables $F_1, F_2,\ldots,F_m, \varepsilon_1, \varepsilon_2,\ldots, \varepsilon_p$ which are unobservable.

The unobservable random vectors F and ε satisfy the following conditions (Johnson and Wichern, 1998):

F and ε are independent.

E(F) = **0**, Cov(F) = **I**

E(ε) = **0**, Cov(ε) = **ψ,** where **ψ** is a diagonal matrix.

Portion of the variance of the *i*th variable contributed by the m common factors is called the *i*th *communality* (h_i^2).

$$h_i^2 = a_{i1}^2 + a_{i2}^2 + \ldots + a_{im}^2$$

The communality measures the percent of variance in a given variable explained by all the factors jointly and may be interpreted as the reliability of the indicator. When an indicator variable has a low communality, the factor model is not working well for that indicator and possibly it should be removed from the model *(http://www2.chass.ncsu.edu/garson/pa765/factor.htm).*

It can also be established that the *correlation* r_{ij} between X_i and X_j is

$$r_{ij} = a_{i1} a_{j1} + a_{i2} a_{j2} + \ldots + a_{im} a_{jm}$$

By using Principal Components Factor Analysis, the unrotated factors can be found as follows:
With p variables there will be the same number of principle components in the form of;

$$Z_1 = b_{11} X_1 + b_{12} X_2 + \ldots\ldots. + b_{1p} X_p$$

$$Z_2 = b_{21} X_1 + b_{22} X_2 + \ldots\ldots. + b_{2p} X_p$$

$$\ldots\ldots..$$

$$Z_p = b_{p1} X_1 + b_{p2} X_2 + \ldots\ldots. + b_{pp} X_p$$

The b_{ij} values are given by the eigenvectors of the correlation matrix (Manly, 1994).

This transformation from X values to Z values is orthogonal, so that the inverse relationship is simply

$$X_1 = b_{11} Z_1 + b_{21} Z_2 + \ldots\ldots. + b_{m1} Z_m + e_1$$

$$X_2 = b_{12} Z_1 + b_{22} Z_2 + \ldots\ldots. + b_{m2} Z_m + e_2$$

$$\ldots\ldots$$

$$X_p = b_{1p} Z_1 + b_{2p} Z_2 + \ldots\ldots. + b_{mp} Z_m + e_p$$

e_i is a linear combination of the principal components Z_{m+1} to Z_p (Manly, 1994).

What we need to do now is to scale the principal components $Z_1, Z_2, \ldots, Z_m$ to have unit variances and make them into proper factors, so Z_i must be divided by its standard deviation, which is $\sqrt{\lambda_i}$, the square root of the corresponding eigenvalue in the correlation matrix. The equations then become (Manly, 1994):

$$X_1 = \sqrt{\lambda_1}\ b_{11} F_1 + \sqrt{\lambda_2}\ b_{21} F_2 + \ldots.. + \sqrt{\lambda_m}\ b_{m1} Z_m + e_1$$

$$X_2 = \sqrt{\lambda_1}\ b_{12} F_1 + \sqrt{\lambda_2}\ b_{22} F_2 + \ldots.. + \sqrt{\lambda_m}\ b_{m2} Z_m + e_2$$

$$\ldots.$$

$$X_p = \sqrt{\lambda_1}\ b_{1p} F_1 + \sqrt{\lambda_2}\ b_{2p} F_2 + \ldots.. + \sqrt{\lambda_m}\ b_{mp} Z_m + e_p$$

Where $F_i = Z_i / \sqrt{\lambda_i}$

The unrotated factor model is then (Manly, 1994):

$$X_1 = a_{11} F_1 + a_{12} F_2 + \ldots\ldots + a_{1m} F_m + e_1$$

$$X_2 = a_{21} F_1 + a_{22} F_2 + \ldots\ldots + a_{2m} F_m + e_2$$

$$\ldots$$

$$X_p = a_{p1} F_1 + a_{p2} F_2 + \ldots\ldots + a_{pm} F_m + e_p$$

Where $a_{ij} = \sqrt{\lambda_j}\ b_{ji}$

Whatever way the provisional factor loadings are determined, it is possible to show they are not unique. There are an infinite number of alternative solutions for the factor analysis model and this leads to the second stage in the analysis, which is called *factor rotation.* Rotation maximizes the loading of each variable on one of the extracted factors whilst minimizing the loading on all other factors. The reference axes of the factors are turned about the origin until some other position has been reached. Since the original factor loadings may not always readily interpretable, it is suggested to rotate them until a simpler structure is achieved.

We can summarize rotation under two distinct categories, oblique rotation and orthogonal rotation. Type of rotation depends largely on relationships of underlying factors; no specific rules have been developed to guide the selection between various methods. Orthogonal rotations are suitable for factor models, which assume the common factors to be independent. Varimax, quartimax and equamax are all orthogonal rotations whilst direct oblimin and promax are oblique rotations.

Orthogonal rotation is the simplest case of rotation; the axes are maintained at 90 degrees. When not constrained to being orthogonal, the rotational procedure is called an oblique rotation.

The coordinate axes can be visually rotated through an angle ϕ. If $\hat{\mathbf{A}}$ is the estimated (p x m) matrix of factor loadings, then the estimated rotated factor loadings matrix $\hat{\mathbf{A}}^* = \hat{\mathbf{A}}\ \mathbf{T}$, where T is an orthogonal transformation matrix satisfying $TT' = T'T = I$. For m=2:

$$T = \begin{bmatrix} \cos\phi & \sin\phi \\ -\sin\phi & \cos\phi \end{bmatrix}$$ for clockwise rotation,

$$T = \begin{bmatrix} \cos\phi & -\sin\phi \\ \sin\phi & \cos\phi \end{bmatrix}$$ for counter clockwise rotation (Johnson and Wichern, 1998).

The estimated covariance or correlation matrix remains unchanged and hence the specific variances and the communalities are also unchanged. Thus, from mathematical point of view there is no difference whether $\hat{A}$ or $\hat{A}^*$ is obtained.

After rotation the obtained matrix is called the *rotated factor matrix* or the *rotated component matrix* ($\hat{\mathbf{A}}^*$) and this shows the factor loadings for each variable onto each factor. The rotation of the factor structure clarifies things considerably and if the variables are listed in the order of size of their factor loadings it's much easier to see which factor loads on which component.

The next step is to look at the content of the variables that load on the same factor and to try to give them names. If factor analysis has some true mathematical meaning, it will be not difficult to identify common themes.

Before using these factors in further analysis it is necessary to test if they are reliable and internally consistent scales. Scale reliability refers to the internal consistency of the items that are used to measure a factor. High internal consistency of the scales is necessary to ensure the accuracy or precision of the scale. Cronbach's coefficient alpha (α) is most commonly used to assess the scale reliability and is given as: $\alpha = k\,p / [\,1 + p\,(\,k - 1\,)\,]$

where k is the number of items and p is the mean inter-item correlation. The value of Cronbach's coefficient alpha is between 0 and 1 and a higher level of α indicates a higher reliability of the scale. As the rule of thumb, it is stated that alpha levels as low as 0,6 are acceptable for new scales (Lau, 1999).

The last stage of an analysis involves calculating the factor scores, which are the values of the factors $F_1, F_2, \ldots, F_m$ for each of the individuals. These quantities are often used as inputs for further statistical analysis. Most computer programs compute the factor scores.

4.2. Method Employed

The main target of this research is to verify the relationship between competitive priorities of the firm, manufacturing objectives and action plans for the next two years according to the framework proposed by Kim and Arnold (1996).

Our questionnaire data, which shows the current position of the sector, includes 15 variables for competitive priorities, 16 variables for manufacturing objectives and 35 variables for action plans. The number of variables made it impossible to see and interpret the single linkages between them. Thus, a series of exploratory factor analyses are conducted in order to group the variables into components and to reduce the number of variables, which can be used in further analyses.

As a starting point data is analyzed in 3 different groups, originated from answers of 3 different questions about competitive priorities, manufacturing objectives and action plans. Factor analysis is applied three times to decrease the number of variables in each group.

The correlation matrices for competitive priorities, manufacturing objectives and action plans are given in Appendix A, B and C respectively. It can be seen that none of variables have correlation values for all the other variables less than 0,3; thus, data is appropriate for factor analyzing.

Factor analysis was deemed an appropriate technique since examination of the correlation matrices suggested relationships between variables and a Bartlett's test of sphericity rejected the hypothesis that the matrix was an identity (Bush and Sinclair, 1991).

Table 4.1. Reliability analysis results

	KMO Measure of Sampling Adequacy	*Cronbach's Alpha Reliability Coefficients*
Competitive Priorities (15 items)	0,635	0,849
Manufacturing Objectives(16 items)	0,681	0,842
Action Plans (35 items)	0,679	0,909

Before starting the analysis the internal consistency of the data is tested. Cronbach's alpha test showed that the data were quite robust and there was no need to discard any variables from the analysis. Results are given in Table 4.1.

In addition, the Kaiser-Meyer-Olkin measure of sampling adequacy, which is a measure of degree of intercorrelations among the variables, was within the range considered acceptable (Table 4.1).

For all the analyses, Principal Component Analysis is used with SPSS 11.0. After reaching an initial factor solution a varimax rotation is made until an agreeable component matrix is obtained. Rotation is based on eigenvalues greater than 1.

To determine the optimum number of factors, a scree tail test is made and the scree plot of each analysis is also included in the results section. Components having eigenvalues greater than 1 are selected as the number of factors extracted.

4.3. Results

4.3.1. Factor Analysis Results for Competitive Priorities

First Attempt:

Companies in the sample are asked to indicate the relative importance of the given 15 competitive priorities for the next two years. The first analysis was made with SPSS using this data consisting of 15 variables and 41 cases.

The scree plot of the analysis is shown below in Figure 4.1. It is decided to group 15 variables into 5 factors. Since the initial solution of factor loadings (Appendix D) does not show a clear solution in grouping the competitive priorities Varimax rotation is used. The rotated component matrix and the factor loadings are shown in Table 4.2.

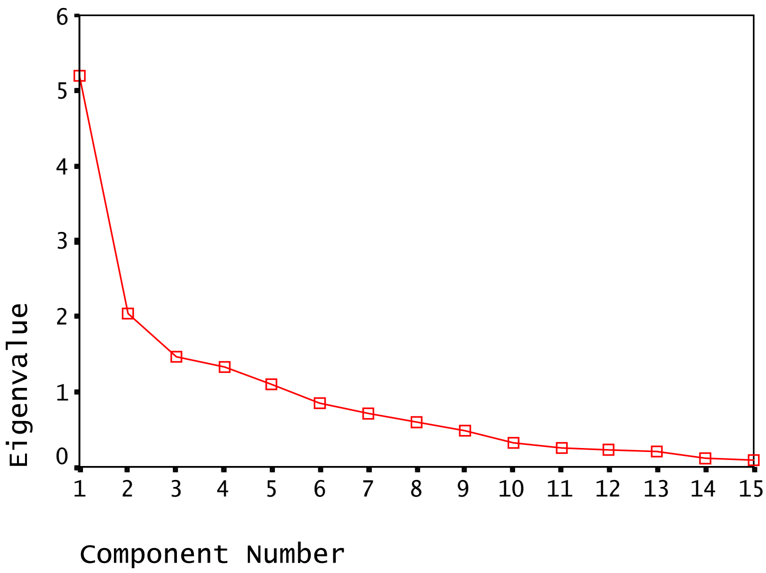


Figure 4.1. Scree plot for 15 competitive priorities

As summarized in Table 4.3, a name is given to each component to represent the content of the competitive priorities included in each group in order to make the results more understandable for further analyses.

As seen in the rotated component matrix in Table 4.2, ‘customize on special products’, ‘high performance products’, ‘durable goods’, ‘consistent quality level’ and ‘reliable products’ are the competitive priorities that loaded on the first factor. These are all related with the properties of the products of the company, so they can be thought as a group to represent product-based competition.

Table 4.2. Rotated component matrix of 15 competitive priorities

	Component				
	1	2	3	4	5
Customize on special products	0,8430	0,1471	0,1597	-0,0994	0,1732
High performance products	0,8338	0,0472	0,0214	0,3777	0,0722
Durable goods	0,7744	-0,1484	0,2986	0,1676	0,0586
Consistent quality level	0,5555	-0,0067	0,5478	0,3958	0,2006
Reliable products	0,4827	0,1963	0,1382	0,4627	-0,3808
Niche market	-0,1350	0,7679	0,1154	0,0532	0,1089
A broad product line	0,3680	0,7453	-0,0108	-0,2275	0,0230
Widespread delivery	-0,0292	0,7335	0,1417	0,3890	0,2167
Rapid adoption to volume changes	0,2396	0,5471	0,4465	0,4122	-0,0474
Dependable deliveries	0,2704	0,0013	0,7339	-0,0953	-0,0605
Rapid design change / New product innovation	0,0788	0,3171	0,7322	-0,1240	0,1933
Rapid deliveries	-0,0146	0,1224	0,6418	0,5493	0,2341
Low price	0,1860	0,0435	-0,1386	0,8195	0,0886
After sales service	0,1489	0,1595	0,1684	0,1603	0,8439
Brand image	0,5785	0,2573	0,0644	-0,0347	0,6126

‘Niche market’, ‘a broad product line’, ‘widespread delivery’ and ‘rapid adoption to volume changes’ are grouped as second factor, they all related with market and define how the company will be differentiated from other companies and type of the competitive strategy of the company in the market.

Table 4.3. Factor analysis results for competitive priorities

Factors	*Factor Loading*
1. PRODUCT (%21,5)	
Customize on special products	0,8430
High performance products	0,8338
Durable goods	0,7744
Consistent quality level	0,5555
Reliable products	0,4827
2. MARKET (%15,2)	
Niche market	0,7679
A broad product line	0,7453
Widespread delivery	0,7335
Rapid adoption to volume changes	0,5471
3. CUSTOMER SATISFACTION (%14,7)	
Dependable deliveries	0,7339
Rapid design change / New product innovation	0,7322
Rapid deliveries	0,6418
4. PRICE (%13,0)	
Low price	0,8195
5. COMPANY IMAGE (%9,8)	
After sales service	0,8439
Brand image	0,6129

'Dependable deliveries', 'rapid design change / new product innovation' and 'rapid deliveries' are in the third group. These all focus on customers and customer satisfaction.

'Low price' stands alone showing the price-based dimension of competition. It was an expected result and is confirmed with factor analysis.

The last group of competitive priorities includes 'after sales service' and 'brand image', which help by positioning the firm in a market and in customers' minds. These competitive priorities target the not directly measurable effects of the manufacturing strategy on customers.

After factor analysis, 74,3% of total variance can be explained by 5 components. The first factor can explain 21,5% of total variance, which is followed with 15,2%, 14,7%, 13,0% and 9,8% from components 2,3,4 and 5 respectively.

The resulting solution is not considered a proper one since it included the competitive priorities ‘niche market’, ‘a broad product line’ and ‘wide delivery’ in the same factor. Recalling that these 3 variables are the least important among all competitive priorities as indicated in Table 3.3, it is decided to repeat the factor analysis procedure after eliminating these 3 variables. Furthermore, the factor loadings for component 2 and 3 of the variable ‘rapid adoption to volume changes’ are too close to each other. This in turn makes the classification of the variables loading to that component more difficult. So, a second analysis is made after discarding these 3 variables.

Second Attempt:

The second factor analysis after discarding 3 variables and the results of the analysis according to these 12 variables are summarized as the second attempt.

The initial and rotated factor solutions are displayed in Appendix E and Table 4.4. The solution has not changed drastically. Number of factors decreased from 5 to 4 with the second factor designated as “Market” in the first attempt being eliminated. Content of each component is the same as the result from the analysis with 15 variables, but the only difference comes from the inclusion of ‘rapid adoption to volume changes’, in the group called here as customer satisfaction.

The suggested grouping of variables is given in Table 4.5. This new solution is more acceptable and the classification is closer to the expected grouping.

First component, explaining 26,8% of total variance is named as ‘product’. ‘Customize on special products’, ‘high performance products’, ‘durable goods’, ‘consistent quality level’ and ‘reliable products’ are 5 product based competitive priorities that build this group.

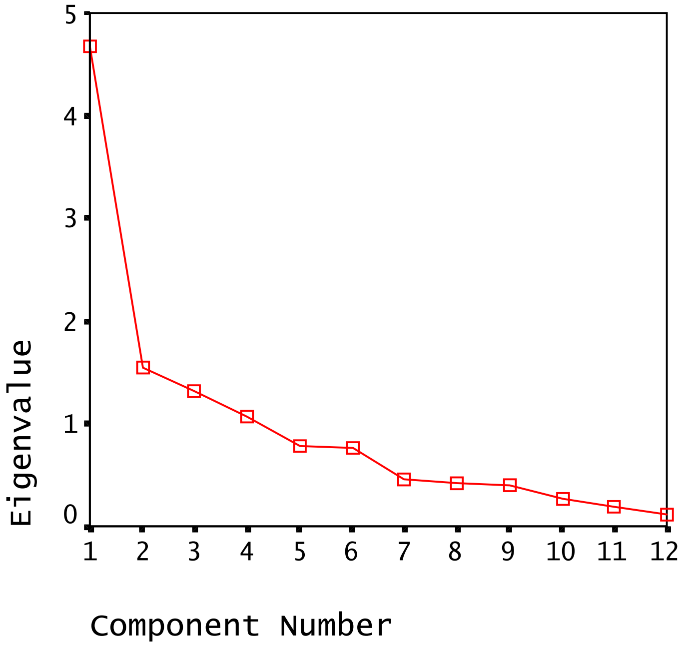


Figure 4.2. Scree plot for 12 competitive priorities

Table 4.4. Rotated component matrix of 12 competitive priorities

	Component			
	1	**2**	**3**	**4**
Customize on special products	0,8454	0,0756	0,2211	-0,0809
High performance products	0,8300	0,0532	0,1386	0,3689
Durable goods	0,6931	0,2008	0,1172	0,0690
Consistent quality level	0,6205	0,5381	0,1629	0,2255
Reliable products	0,5676	0,2023	-0,2776	0,3808
Rapid design change / New product innovation	0,0514	0,7670	0,2715	-0,3144
Rapid deliveries	0,0978	0,7554	0,1000	0,3266
Rapid adoption to volume changes	0,1863	0,7031	0,1450	0,3193
Dependable deliveries	0,4497	0,5558	-0,2369	-0,2754
After sales service	0,1128	0,2512	0,8535	0,0715
Brand image	0,5857	0,0826	0,6537	-0,0360
Low price	0,1510	0,1030	0,0443	0,8613

Second factor can be named as 'responsiveness', which can explain the total variance with a respective rate of 20,2%. 'After sales service' and 'brand image' are the two competitive priorities, which build the third and the 12,5% of the variance-explaining component. The last group consists of a single priority that is 'low price'. Variance explained by this component is 12,3%.

Table 4.5. Factor analysis results for competitive priorities

Factors	*Factor Loading*
1. PRODUCT (%26,8)	
Customize on special products	0,8454
High performance products	0,8300
Durable goods	0,6931
Consistent quality level	0,6205
Reliable products	0,5676
2. RESPONSIVENESS (%20,2)	
Rapid design change / New product innovation	0,7670
Rapid deliveries	0,7554
Rapid adoption to volume changes	0,7031
Dependable deliveries	0,5558
3. COMPANY IMAGE (%12,5)	
After sales service	0,8535
Brand image	0,6537
4. PRICE (%12,3)	
Low price	0,8613

4.3.2. Factor Analysis Results for Manufacturing Objectives

Classification and grouping of manufacturing objectives are accomplished using the responses to a question that asked the respondents to evaluate a list of 16 given manufacturing objectives according to their importance for the next two years.

First Attempt:

As is visible from the results of scree plot test (Figure 4.3), the acceptable number of factors, that have eigenvalues greater than 1 is six.

Like the projection of competitive priorities factor analysis results, the initial and rotated component matrices and the corresponding factor loadings can be seen in Appendix F and Table 4.6 below.

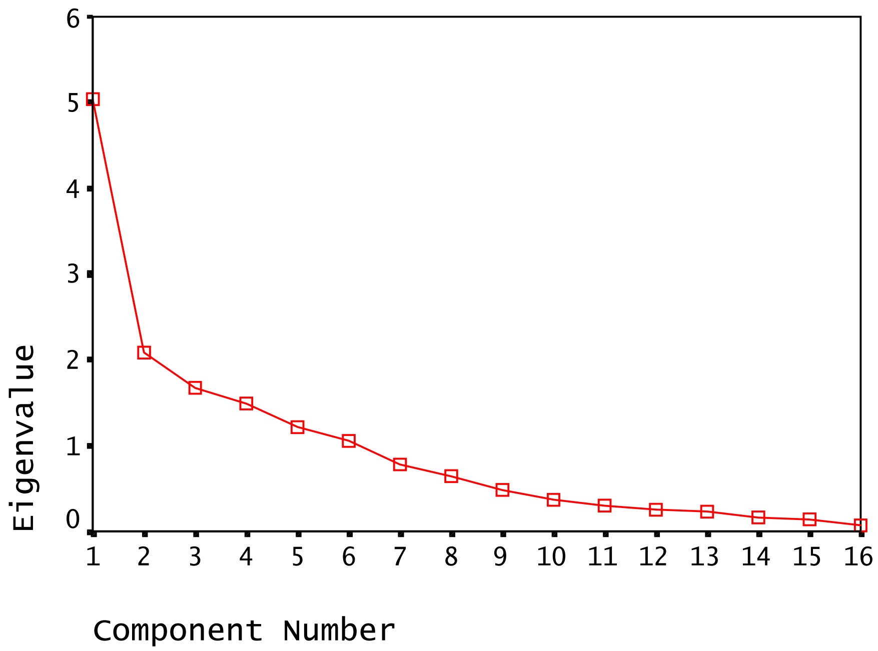


Figure 4.3. Scree plot for 16 manufacturing objectives

As summarized in Table 4.7, the first group of variables explaining 15,1% of total variance can be named as manufacturing objectives aiming to increase the speed of production.

The group following these 2 manufacturing objectives includes 'increasing direct labor productivity', 'decreasing unit cost', 'increasing conformance quality' and 'reducing break-even point', which explain 15,1% of total variance. The objectives in this second component are all related with performance of manufacturing, cost and productivity.

Table 4.6. Rotated component matrix of 16 manufacturing objectives

	Component					
	1	**2**	**3**	**4**	**5**	**6**
Increase production rate	0,8170	0,2977	0,0546	0,0968	0,1086	-0,0472
Reduce production flow time	0,7373	0,2799	0,1247	0,2794	0,0389	0,2202
Increase direct labor productivity	0,4137	0,7842	0,0256	0,0424	-0,0274	-0,2823
Decrease unit cost	0,2000	0,7451	0,2568	0,0343	0,0690	0,2432
Increase conformance quality	0,0480	0,7434	-0,1513	0,0263	0,2688	0,1138
Reduce break-even points	0,3838	0,4554	0,3231	0,3033	-0,0656	0,0916
Increase end products stock turnover rate	0,2006	-0,0704	0,9089	0,1554	0,0773	0,0019
Increase input materials stock turnover rate	-0,0237	0,1962	0,8763	0,1794	0,1156	0,1358
Decrease new product development time	0,0138	0,0207	0,1470	0,9337	0,0587	0,0941
Decrease new product introduction time	0,3881	0,0839	0,2077	0,8393	0,0458	0,0983
Decrease breakdowns and not planned stops	-0,2713	0,0590	0,2164	-0,0478	0,8480	-0,0316
Reduce set-up / changeover times	0,4666	-0,0074	0,2110	-0,0556	0,6705	-0,0115
Reduce production lead time	0,4084	0,2052	-0,3162	0,2226	0,6406	0,0762
Increase delivery reliability	0,1440	0,3293	-0,0046	0,3153	0,5414	0,3527
Increase market share	-0,1574	0,2919	-0,0672	0,3285	0,0043	0,7480
Producing high value added products	0,3929	-0,1601	0,3352	-0,0786	0,0919	0,7441

As the third important and 13,6% of total variance explaining factor stands inventory-holding policy. ‘Increasing end products stock turnover rate’ and ‘increasing input materials stock turnover rate’ are the manufacturing objectives forming this component.

Reducing new product development and introduction time are forming the next group about new product development with property of explaining 13,0% of total variance.

Fifth component includes different manufacturing objectives from different areas, so it is not easy to give a name to this group. It was also the reason to make a second factor analysis with eliminating some variables. This group can explain 12,5% of total variance.

The last group can be seen as the group of manufacturing strategies, which directly target the marketing strategy of the company. Increasing market share and producing high value added products are the variables in this component, they can explain 9,3% of total variance together.

Second Attempt:

A second factor analysis is conducted using 14 manufacturing objectives. Two variables, 'increase input materials stock turnover rate' and 'increase end products stock turnover rate' got the highest level of 1 and 2 answers, which mean "1=not important" and "2=less important". So, the answers to these 2 manufacturing objectives are discarded and new data set is analyzed using SPSS. The initial results are shown in Appendix G.

As we can see from the scree plot in Figure 4.4, five components have eigenvalues greater than 1, so the number of components is reduced to 5 after the second analysis. As expected, the content of the groups did not change; the group consisting of discarded variables disappeared. (Table 4.7) The only difference is the change of factor loadings.

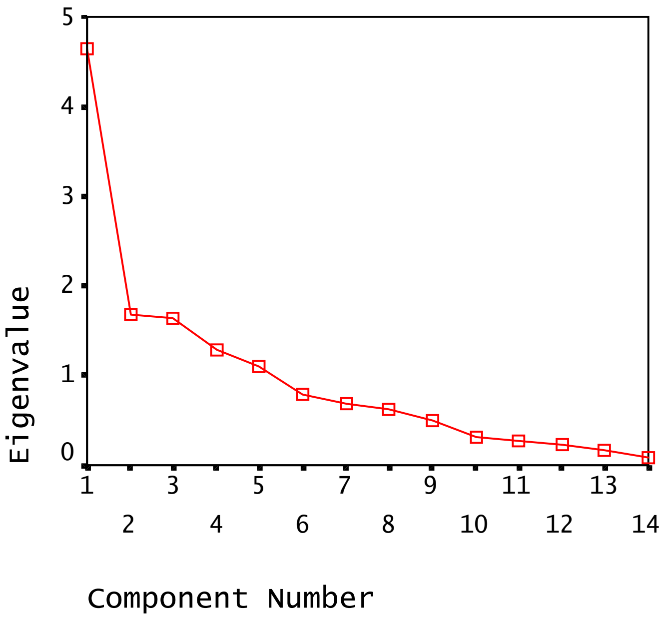


Figure 4.4. Scree plot for 14 manufacturing objectives

Table 4.7. Rotated component matrix of 14 manufacturing objectives

	Component				
	1	**2**	**3**	**4**	**5**
Increase conformance quality	0,7480	0,0154	0,0174	0,2661	-0,0009
Increase direct labor productivity	0,7440	0,4678	0,0318	-0,0311	-0,3034
Decrease unit cost	0,7364	0,2265	0,0736	0,0556	0,2603
Reduce break-even points	0,4681	0,3991	0,3415	-0,0467	0,1335
Increase production rate	0,2849	0,8080	0,1239	0,1025	0,0242
Reduce production flow time	0,2812	0,6887	0,3445	0,0181	0,2853
Decrease new product development time	0,0190	0,0262	0,9407	0,0822	0,0376
Decrease new product introduction time	0,0931	0,3939	0,8589	0,0782	0,0976
Decrease breakdowns and not planned stops	0,0443	-0,2310	-0,0538	0,8434	0,0010
Reduce set-up / changeover times	-0,0730	0,4996	-0,0306	0,6641	0,1347
Reduce production lead time	0,2353	0,2812	0,2246	0,6452	-0,0143
Increase delivery reliability	0,3599	0,0258	0,3691	0,5213	0,3055
Producing high value added products	-0,0591	0,3454	0,0033	0,1329	0,8631
Increase market share	0,3715	-0,3152	0,3894	-0,0251	0,6138

The order and factor loadings of the variables did change, but the groupings are almost the same as explained before. The highlighted cells show which variable loads to which component. The final results and total variance explained by each component are summarized in the following table. With this grouping, 74,1% of total variance can be explained.

Table 4.8. Factor analysis results for manufacturing objectives

Factors	*Factor Loading*
1. DECREASING PRODUCTION COST (%17,0)	
Increase conformance quality	0,7480
Increase direct labor productivity	0,7440
Decrease unit cost	0,7364
2. INCREASING PRODUCTION EFFICIENCY (%15,6)	
Increase production rate	0,8080
Reduce production flow time	0,6887
3. NEW PRODUCT DEVELOPMENT (%15,9)	
Decrease new product development time	0,9407
Decrease new product introduction time	0,8589
4. PROCESS IMPROVEMENT (%14,0)	
Decrease breakdowns and not planned stops	0,8434
Reduce set-up / changeover times	0,6641
Reduce production lead time	0,6452
5. POSITIONING THE COMPANY IN THE MARKET (%10,7)	
Increase market share	0,8631
Producing high value added products	0,6138

4.3.3. Factor Analysis Results for Action Plans

Since the number of variables, in our case the number of action plans, is more than the variables of competitive priorities and manufacturing objectives, it is more difficult to group these variables using factor analysis. The companies were asked to evaluate their emphasis on 35 action plans for the past two years. A series of analyses is made until reaching an agreeable solution. All solutions are shown below.

First Attempt:

First analysis is made using data consisting of 35 action plans and the answers of 41 companies in 5 point Likert scale. As shown in the initial and rotated factor solution matrices below, the results were not satisfactory. (Appendix H and Table 4.9)

After factor analysis 35 action plans were reduced to 10 components. Although taking the minimum required loading to include a variable in a group is increased to 0,6; most of the groupings were still meaningless. This grouping can explain 82,4% of the total variance cumulatively.

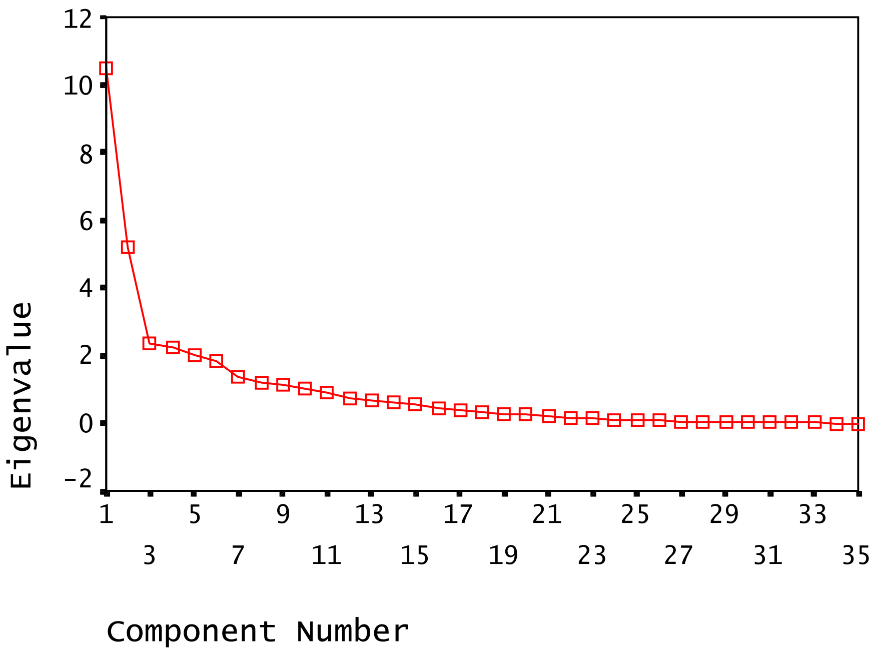


Figure 4.5. Scree plot for 35 action plans

Table 4.9. Rotated component matrix of 35 action plans

	Component									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Production automation	0,8561	0,0744	0,0458	0,0716	0,0923	0,1735	0,0074	0,0151	0,0576	0,2064
Using internet in supply chain	0,7934	-0,0156	0,3032	0,0228	0,1200	0,0193	-0,0329	0,1282	-0,1718	-0,0220
Quality certificates for products	0,7871	-0,0109	-0,0290	0,1731	0,2276	0,2347	-0,2139	0,1042	0,1223	0,0092
Quality certificates for environment protection	0,7473	-0,0990	0,4219	0,1264	0,0928	-0,1273	-0,1221	-0,0587	0,1130	-0,1336
Zero defect	0,6984	0,0695	0,1729	0,3520	0,2001	-0,0005	0,2225	0,1315	0,2036	0,0280
Quality certificates for processes and management	0,6602	0,0632	0,1754	0,0651	-0,0614	0,2764	0,1503	0,0611	0,3113	-0,1454
Improvement of QC lab facilities	0,5787	-0,1466	0,1109	0,5186	0,4569	0,1457	-0,0102	-0,1445	-0,1468	-0,0902
JIT procurement	0,0927	0,8529	-0,2678	-0,0696	-0,0725	0,1107	-0,0793	-0,0210	0,0820	0,0813
Developing new processes for existing products	-0,2866	0,7866	0,0314	0,0201	0,0880	0,0566	0,1675	0,0686	0,1942	-0,0206
Developing new processes for new products	0,3262	0,7310	0,0386	-0,1271	0,0617	-0,0604	0,2858	0,1772	0,0981	0,1177
Restructuring	-0,1056	0,7096	0,3722	0,0051	-0,0588	0,0477	-0,3126	-0,0869	0,0098	0,1982
Integration of information systems of functions	0,1664	0,7095	-0,1267	0,1511	0,0174	0,0902	0,3638	-0,0537	-0,4429	-0,0846
Linking manufacturing strategy to business strategy	-0,0152	0,6629	-0,0582	0,1958	-0,3632	-0,1351	0,2936	0,0890	-0,3953	0,1236
JIT production	-0,0828	0,6559	-0,2082	0,0858	0,2628	0,1855	0,1907	0,2087	0,2399	0,3555
Energy saving	0,3336	-0,0347	0,7034	0,3551	0,0992	0,2343	-0,0301	0,0501	-0,0546	0,0037
Conformance to environmental standards	0,2662	-0,1659	0,6475	0,2418	0,0233	0,1482	-0,2066	0,0812	0,2613	-0,0033
Preventive maintenance	0,3342	-0,0076	0,6338	0,2936	0,2665	0,1532	0,1963	0,2051	0,0706	-0,0131

Table 4.9. Rotated component matrix of 35 action plans (continued)

	Component									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Green production technologies	0,5257	0,0079	0,5694	0,0858	0,2744	0,1785	0,0345	-0,0824	0,1107	0,0914
Value engineering / Redesign of products	0,0277	0,1922	0,1277	0,8244	0,0725	0,1777	-0,1138	0,1593	0,0562	-0,1557
Quality circles / Quality improvement teams	0,4121	-0,0353	0,2079	0,7157	-0,1495	0,0438	0,0285	-0,0253	0,0226	-0,0162
Activity based costing (ABC)	0,1685	-0,1135	0,2886	0,7151	0,1919	-0,1646	-0,0673	0,0144	0,3320	0,3016
Statistical process control	0,1078	-0,0473	0,4835	0,5289	0,2961	0,3561	-0,0040	-0,0158	-0,0435	-0,0204
Improvement of supplier relationships	0,1210	0,0123	0,1316	0,0390	0,8012	-0,0663	0,2113	0,1042	-0,0415	0,2612
Reducing setup / changeover times	0,4301	0,1367	0,1540	0,0730	0,7148	0,1033	-0,1398	0,0616	0,2005	-0,2173
Training of managers	0,4603	-0,1950	0,2877	0,1888	0,5645	0,2488	0,0609	0,2243	0,1120	0,0806
Warehouse management	0,3305	0,1693	0,1277	0,0397	0,0640	0,8302	-0,0737	0,0225	-0,0268	0,0872
Improving after sales service	0,0722	0,0449	0,2897	0,1480	0,0562	0,7602	0,0607	0,2243	-0,1160	-0,1795
Cross-functional teams	-0,0583	0,1525	-0,1341	-0,0672	-0,0725	-0,1672	0,8829	-0,0079	-0,1348	0,0318
Employee empowerment	0,0004	0,1656	0,1152	-0,0474	0,2204	0,1852	0,7745	0,0972	0,1350	0,1336
Manufacturing resource planning	0,2333	-0,1774	0,2402	0,2155	0,0435	0,0580	-0,1888	-0,6822	0,3644	-0,2390
Computer aided design (CAD)	0,3215	-0,0016	0,0833	0,2363	-0,1117	0,4408	-0,0117	0,6742	0,2130	0,1611
Aligning customer needs and product development	0,1584	0,2307	0,1729	0,2249	0,3735	0,1150	-0,0190	0,6638	0,2833	-0,0783
Training of employees (Excluding managers)	0,2050	-0,0781	0,4463	-0,0001	0,3750	0,1241	0,0404	0,6177	-0,1498	-0,2066
Automation of production and inventory control systems	0,3094	0,2419	0,0761	0,1992	0,0751	-0,1442	0,0299	0,0137	0,7951	0,0611
Total Quality Management program	0,0456	0,3613	0,0123	-0,0472	0,0802	-0,0479	0,1337	0,0457	0,0193	0,8100

Second Attempt:

Since the procedure of analyzing all 35 action plans together did not result in a satisfactory solution, the number of action plans is reduced to apply factor analysis again to the reduced data set. To reduce the data set to a smaller number of variables, 3 methods were used:

As a starting data set, the first 20 action plans according to their mean emphasis have been selected and factor analysis applied.

The same procedure also is applied to the data set consisting of the most applied 20 action plans. These 20 action plans are selected according to the percentage of the firms that have used this action plans in past two years.

The next application is made using the 27 action plans. These 27 action plans were either in the list of most used 20 action plans or in the list of most important 20 action plans.

The results are listed in order of selected 27 action plans; most important 20 action plans and most used 20 plans in the following pages.

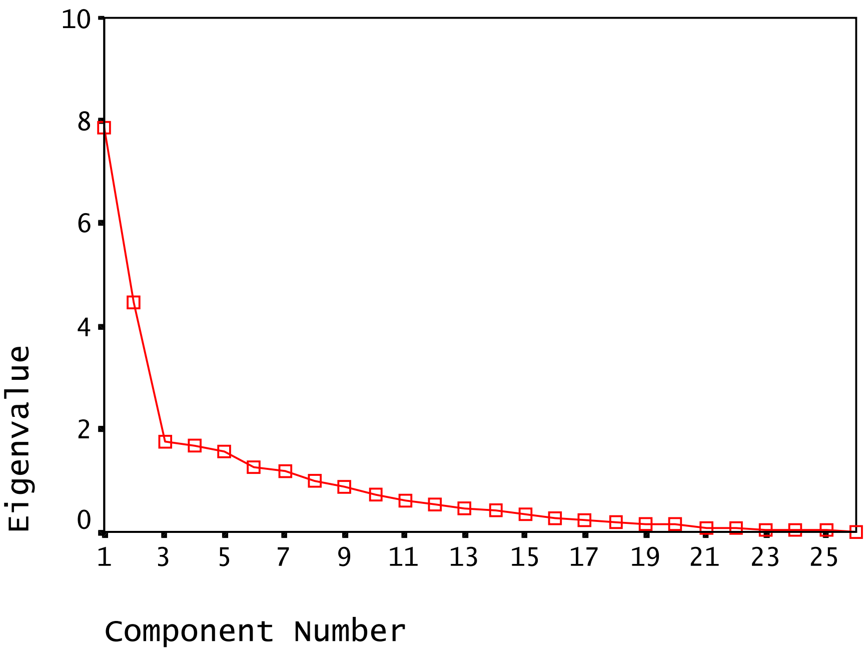


Figure 4.6. Scree plot for selected 27 action plans

Table 4.10. Rotated component matrix of selected 27 action plans

	Component						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Production automation	0,9039	0,1327	0,0883	0,0666	0,0122	-0,0176	0,0723
Quality certificates for products	0,8285	-0,1322	0,1432	0,1035	0,1095	0,1014	0,1941
Quality certificates for processes and management	0,7542	0,0892	0,0514	0,1015	0,2332	-0,0453	0,0848
Zero defect	0,7220	0,1953	0,2159	0,4347	-0,0335	-0,0840	0,1097
Green production technologies	0,6086	-0,0148	0,3690	0,3610	0,1488	0,0455	-0,0997
Linking manufacturing strategy to business strategy	-0,1735	0,8374	-0,3164	0,0907	0,0860	0,1014	-0,0679
Integration of information systems of functions	0,0730	0,7904	-0,0198	-0,0137	0,2414	0,2338	-0,2521
Developing new processes for new products	0,2287	0,7663	0,1463	-0,0767	-0,0071	0,1949	0,1471
Total Quality Management program	0,0579	0,5928	0,1409	0,0339	-0,3568	0,0416	0,2279
JIT production	0,0354	0,5746	0,2309	-0,0153	-0,1101	0,4623	0,4204
Employee empowerment	0,0267	0,5033	0,4947	0,0188	0,0887	-0,1146	0,0198
Improvement of supplier relationships	0,1484	0,1030	0,8540	0,0787	-0,0885	0,0323	0,0171
Training of managers	0,4753	-0,0845	0,6141	0,2513	0,2593	-0,1601	0,2130
Reducing setup / changeover times	0,5382	-0,1443	0,5855	0,1424	0,0695	0,2874	0,0388
Training of employees (Excluding managers)	0,1933	-0,0921	0,5851	0,1405	0,5199	-0,0502	0,1476
Activity based costing (ABC)	0,1878	-0,0869	0,1118	0,8378	-0,2859	0,0000	0,2595
Value engineering / Redesign of products	0,1227	-0,0328	-0,0360	0,6753	0,2675	0,3699	0,1621
Preventive maintenance	0,3085	0,1418	0,3454	0,6517	0,3221	-0,1795	0,0431
Energy saving	0,4200	-0,0675	0,2140	0,6060	0,4288	0,0487	-0,1613
Improving after sales service	0,1215	0,0757	0,0704	0,1324	0,8292	-0,0320	0,2376
Warehouse management	0,5032	0,0677	0,0792	-0,0494	0,6040	0,2387	0,1063
Restructuring	0,0655	0,2234	-0,0325	0,1727	0,0194	0,8054	-0,1020
Developing new processes for existing products	-0,2373	0,5149	0,1406	0,0081	0,0698	0,6158	0,1423
JIT procurement	0,1466	0,5707	-0,1876	-0,2685	-0,0492	0,6005	0,1370
Computer aided design (CAD)	0,3203	0,0918	-0,0293	0,2135	0,3624	-0,0838	0,7668
Aligning customer needs and product development	0,1646	0,0837	0,4557	0,2385	0,2459	0,1972	0,6056
Improving after sales services	-0,0485	0,1026	0,2532		0,3954	0,1525	0,7079

Since we wanted to see the whole picture of the machine manufacturing industry, we wanted to keep as many action plans as possible in the analyses. So, starting with the results of the selected 27 action plans was not a wrong decision. But like in the first attempt, this grouping was also not satisfactory.

The list of these 27 action plans can be seen in Table 4.10 and Appendix I. After conducting scree plot test, the number of components was selected as 7, which shows the number of components having eigenvalues larger than 1. Highlighted cells in Table 4.10 show the factor loadings of 27 variables into 7 components. After examining the content of each group, it is easy to see that the members of the components have no shared purpose or target.

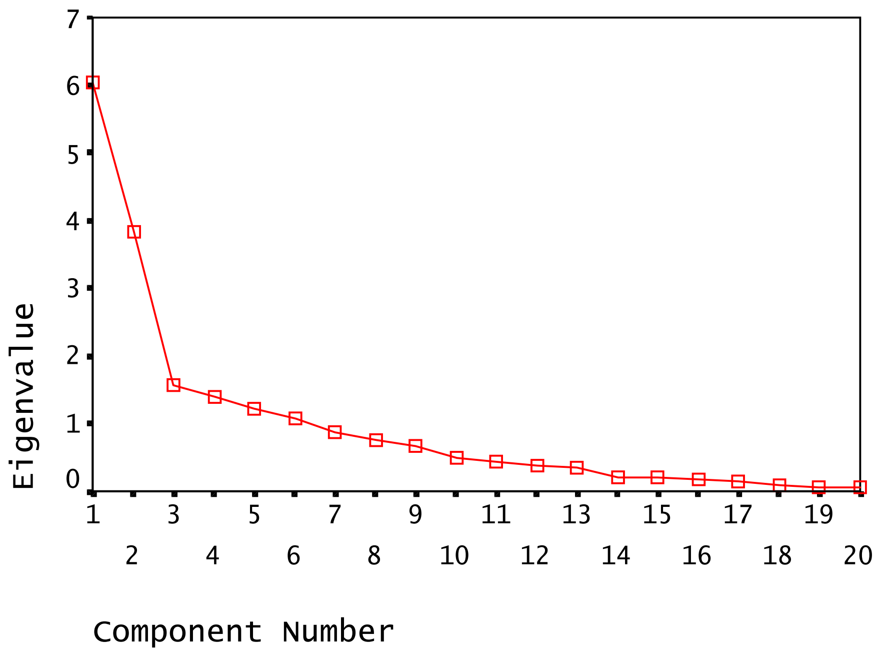


Figure 4.7. Scree plot for the most important 20 action plans

Analysis of the as most important evaluated 20 action plans yielded to a better solution than selected 27 action plans. The list of action plans can be seen in Table 4.11. Scree plot test gave the number of components having eigenvalues greater than 1 as 6. As distinctly interpreted from highlighted cells in Table 4.11, all groups are not fitting well.

Table 4.11. Rotated component matrix of the most important 20 action plans

	Component					
	1	2	3	4	5	6
Production automation	0,8766	0,1450	0,0277	0,0393	0,0422	0,1172
Quality certificates for products	0,8278	-0,1152	0,0910	0,2077	0,1378	-0,0022
Zero defect	0,8233	0,1591	0,1879	0,0976	-0,0752	0,2349
Quality certificates for processes and management	0,7746	0,1164	-0,0251	0,2170	-0,0118	-0,0648
Green production technologies	0,7107	-0,0727	0,2941	0,1417	0,0086	0,1173
Reducing setup / changeover times	0,6152	-0,1687	0,5530	0,0950	0,2871	-0,1393
Integration of information systems of functions	0,0996	0,8514	0,0812	-0,0130	0,1109	-0,2238
Linking manufacturing strategy to business strategy	-0,1577	0,8449	-0,2664	0,0426	0,1000	0,1085
Developing new processes for new products	0,1998	0,7305	0,1613	0,1008	0,2811	0,0857
JIT production	-0,0394	0,5168	0,3505	0,2482	0,5148	0,2285
Improvement of supplier relationships	0,1889	0,0259	0,8648	-0,0112	0,0250	0,1379
Employee empowerment	0,0668	0,4869	0,5585	0,0839	-0,2414	0,0723
Training of managers	0,5406	-0,1516	0,5562	0,3741	-0,1397	0,0975
Improving after sales services	0,1657	0,0790	0,0373	0,8065	-0,0667	-0,2500
Computer aided design (CAD)	0,3160	0,0649	-0,0645	0,8018	-0,0210	0,2848
Aligning customer needs and product development	0,2376	0,0205	0,3973	0,6384	0,2717	0,1754
Restructuring	0,0691	0,1933	-0,0468	-0,0231	0,8049	0,1000
JIT procurement	0,0226	0,6135	-0,0982	-0,0082	0,6555	-0,0924
Activity based costing (ABC)	0,3319	-0,2413	0,1115	0,1294	0,0105	0,7463
Total Quality Management program	-0,0445	0,4733	0,1600	-0,0913	0,2082	0,6308

The best result is achieved from analysis of most used 20 action plans. 20 variables loaded into 6 components and the initial solution and rotated component matrices are available as Appendix K and Table 4.12.

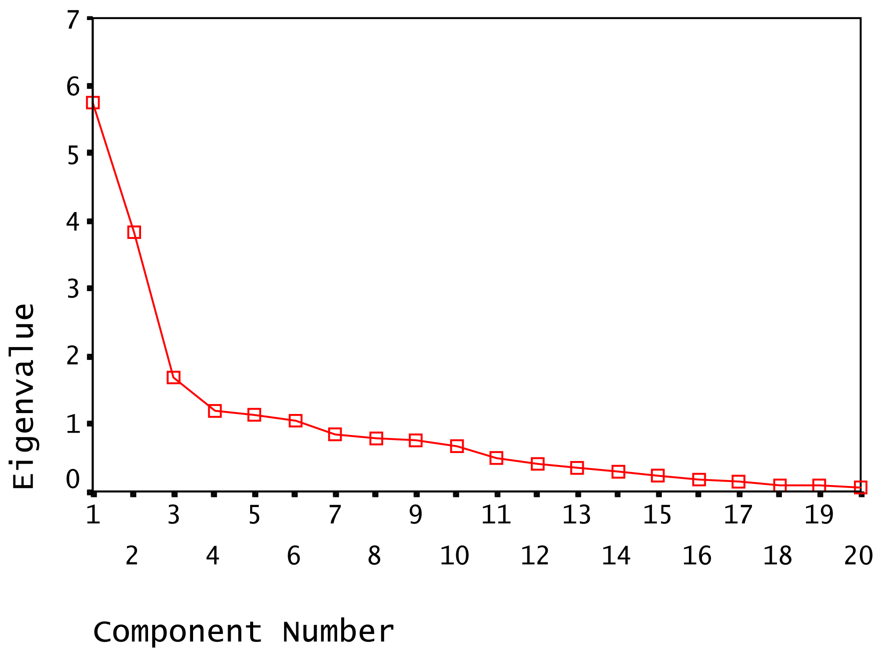


Figure 4.8. Scree plot for the most used 20 action plans

Although the grouping of the action plans solution looks like not fitting to the meaning of the action plans, after selecting the minimum factor loading to load a variable on a specific component to be greater than 0,6; the solution becomes more meaningful. Six components are named as process development and improvement, training, quality certificates, customer focus, restructuring and after sales service. Total variance explained using this grouping is 73,2%.

As summarized in Table 4.13, the first common factor can be named as the group of action plans about process development and improvement of existing processes. 'JIT procurement', 'JIT production', 'developing new processes for new products', 'developing new processes for existing products', 'integration of information systems of functions' and 'total quality management' are the concepts to be counted in this group, which explains 19,8% of total variance.

The second component, which explains 14,0% of total variance, is about training. 'Training of managers' and 'training of employees except managers' are directly in the concept of training and 'improving supplier relationships' is directly related with training, it shows the change of company culture.

Table 4.12. Rotated component matrix of the most employed 20 action plans

	Component					
	1	**2**	**3**	**4**	**5**	**6**
JIT procurement	0,8206	-0,3386	0,1072	0,0199	0,1286	-0,0033
JIT production	0,8147	0,1268	-0,0234	0,2788	0,0668	-0,0107
Developing new processes for new products	0,7901	0,1324	0,1614	0,0527	-0,0635	0,1082
Developing new processes for existing products	0,7177	-0,0126	-0,3379	0,1688	0,2883	0,1660
Integration of information systems of functions	0,6534	0,0188	0,0126	-0,2628	0,1197	0,4785
Total Quality Management program	0,6388	0,2037	0,0953	-0,0645	-0,1759	-0,2408
Improvement of supplier relationships	0,2112	0,8182	0,0703	0,0412	-0,0353	-0,1495
Training of managers	-0,0923	0,6979	0,4469	0,3189	0,0258	0,1121
Training of employees (Excluding managers)	-0,1378	0,6155	0,1698	0,4224	0,1966	0,1528
Preventive maintenance	-0,0482	0,5834	0,3694	0,0909	0,3083	0,2987
Employee empowerment	0,4060	0,5074	-0,0824	-0,0488	-0,1937	0,3986
Quality certificates for products	0,0197	0,1747	0,8076	0,2364	0,1015	-0,0579
Quality certificates for processes and management	0,0834	0,1430	0,7871	0,1150	0,0343	0,1313
Warehouse management	0,1724	0,0546	0,5842	0,1491	0,1954	0,4931
Computer aided design (CAD)	0,0935	0,0438	0,3748	0,7635	0,0181	0,2395
Aligning customer needs and product development	0,2223	0,4265	0,1301	0,7352	0,2042	-0,0062
Value engineering / Redesign of products	0,0101	0,1018	0,1054	0,2770	0,7046	0,2208
Restructuring	0,5324	-0,1141	0,0723	-0,0888	0,6631	-0,1670
Energy saving	-0,1609	0,4581	0,5208	-0,0420	0,5865	0,1842
Improving after sales services	-0,0485	0,1026	0,2532	0,3954	0,1525	0,7079

Third component has only action plans aiming to get quality certificates. ‘Quality certificates for products’ and ‘quality certificates for process and management’ are two members of this group. This group can easily be named as the component for quality certificates which builds 13,3% of total variance.

Table 4.13. Suggested factor analysis result for action plans

Factors	*Factor Loading*
1. PROCESS DEVELOPMENT - IMPROVEMENT (%19,8)	
JIT procurement	0,8206
JIT production	0,8147
Developing new processes for new products	0,7901
Developing new processes for existing products	0,7177
Integration of information systems of functions	0,6534
Total Quality Management program	0,6388
2. TRAINING (%14,0)	
Improvement of supplier relationships	0,8182
Training of managers	0,6979
Training of employees (Excluding managers)	0,6155
3. QUALITY CERTIFICATES (%13,3)	
Quality certificates for products	0,8076
Quality certificates for processes and management	0,7871
4. CUSTOMER FOCUS (%9,7)	
Computer aided design (CAD)	0,7635
Aligning customer needs and product development	0,7352
5. PRODUCT AND PROCESS RESTRUCTURING (%8,6)	
Value engineering / Redesign of products	0,7046
Restructuring	0,6631
6. AFTER SALES SERVICES (%7,8)	
Improving after sales services	0,7079

Fourth group of action plans consists of 'computer aided design (CAD)' and 'aligning customer needs and product development'. These are action plans, which emphasize a strong customer focus. So, this group can be named as customer focus.

The last group consists of a single action plan, 'improving after sales services', which explains 7,8% of total variance. This sixth component is named as after sales services.

4.4. Summary

In this chapter, we completed the factor analysis for the three stages of manufacturing strategy development, reducing the large number of variables into smaller sets of factors:

- From among the initial set of 15 competitive priorities in the survey, 12 were selected through critical reasoning. These in turn were represented by 4 factors following factor analysis. Four groups of competitive priorities are named as product, responsiveness, company image and price.
- 16 manufacturing objectives were first reduced to 14 variables before applying factor analysis, and were then grouped into 5 factors. These factors are: Manufacturing objectives to increase production rate, manufacturing objectives to decrease production costs, manufacturing objectives to improve processes, manufacturing objectives to new product development, manufacturing objectives of positioning the company in the market.
- 20 out of the initial 35 action plans in the survey were selected. This selection was based on their rankings with respect to the percentage of firms selecting the particular plan. Through factor analysis, these 20 variables were reflected through 6 factors. These are process development and improvement, training, quality certificates, customer focus, restructuring and after sales services.

We found out that eliminating some of the variables before applying factor analysis enabled us to obtain more meaningful results. These variables were eliminated either because the related data was missing for most companies, or they had relatively low average values implying that they were among the least significant variables.

At the end of the factor analysis, factor scores are calculated for each component for each company. Three matrices obtained with respective sizes of 41x4 for competitive priorities, 41x5 for manufacturing objectives and 41x6 for action plans. These factor scores will be used in Chapter 5 when profiling company groups obtained through cluster analysis.

5. CLUSTER ANALYSIS

In Chapter 4, factor analysis is used to group the questions (variables) into groups in order to reduce the number of variables. The aim of this chapter is to group companies according their answers to 3 questions about importance of given competitive priorities, importance of given manufacturing objectives and the emphasis of given action plans for the past two years. Second target is giving the current profile of the respondents, which will also represent the profile of Turkish machine manufacturing industry.

At the beginning of the chapter, a brief introduction to cluster analysis is made. Alternative methods to conduct a hierarchical cluster analysis are covered in this part, which is followed by the explanation of the methodology used by analyzing of the current data. Results and comments are discussed at the end of the chapter.

5.1. Introduction to Cluster Analysis

As we have seen in section 4.3, variables can be grouped using factor analysis according to their shared variance. Cluster analysis is a similar technique, but in this case we try to group the cases instead of variables. In this study, we try to detect the natural relationships and groupings of the firms according to the questionnaire data. So, in the following part a cluster means a group of firms in the Turkish machine manufacturing industry at a particular location.

The clusters formed with this family of methods should be highly internally homogenous (members are similar to one another) and highly externally heterogeneous (members are *not* like members of other clusters).

There are many algorithms to conduct a cluster analysis. Clustering methods may be top down and employ logical division, or bottom up and undertake aggregation. Aggregation procedures, which are based upon combining cases through assessment of similarities, are the most common and popular techniques.

5.1.1. Similarity Measures in Clustering

The two key steps within cluster analysis are the measurement of distances between objects and to group the objects based upon the resultant distances (linkages).

There are four types of similarity measures (Aldenderfer and Blashfield, 1984):

a. Correlation coefficients
b. Distance measures
c. Association coefficients
d. Probabilistic similarity coefficients

Each of these methods has advantages and disadvantages that must be considered before a decision is made to use one. Only correlation and distance coefficients have widespread use in social sciences, numerical taxonomists and biological sciences use the others.

5.1.1.1. Correlation coefficients

We know that the correlation coefficient shows whether as one variable changes the other variable changes by a similar amount and thus it is a measure of similarity between two variables. The most popular of the correlation coefficients is the Pearson Correlation coefficient, which can be calculated as follows (Aldenderfer and Blashfield, 1984):

$$r_{jk} = \frac{\Sigma (x_{ij} - \overline{x}_j) (x_{ik} - \overline{x}_k)}{\sqrt{\Sigma (x_{ij} - \overline{x}_j)^2 (x_{ik} - \overline{x}_k)^2}}$$

The value of coefficient ranges from –1 to +1 and a value of 0 indicates no relationship between cases.

In theory, the simple correlation coefficient can be used to identify the similarity between the variables, but it ignores information about the elevation of scores. The correlation coefficient is frequently described as a shape measurement, in that it is insensitive to differences in the magnitude of the variables used to compute the coefficient. Therefore, although the correlation coefficient tells us whether the pattern of responses between variables is similar, it doesn't tell us anything about the distance between variables.

5.1.1.2. Distance measures

To discover the natural groupings of variables it is necessary to develop a quantitative scale on which to measure the association between objects. The distances provide for a measure of similarity between objects and may be measured in a variety of ways. One way is to look at the closeness between each pair of objects in order to determine their similarity. Another way is using the distance as the complement of similarity and to look at the distance or difference between the pairs of objects.

The most commonly used measure of similarity is Euclidean distance. It is the geometric distance between two objects and the distance between two arbitrary points A and B with coordinates $A = [x_1 , x_2 , \ldots , x_p]$, $B = [y_1 , y_2 , \ldots , y_p]$ can be calculated as follows:

$$d\,(A,B) = \sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2 + \ldots\ldots + (x_p - y_p)^2}$$

The cases are more similar as the distance is smaller. But the Euclidean distance is sometimes unsatisfactory for statistical purposes, because each coordinate of the variable contributes equally while calculating the distance. This measure is heavily affected by variables with large size or dispersion differences. So, if cases are being compared across variables that have very different variances then the Euclidean distances will be inaccurate. As such it is important to standardize scores before proceeding with the analysis. Standardizing scores is especially important if variables have been measured on different scales.

Several options other than simple Euclidean distance measure are also available. For example, since calculating the square root does not change the distance the points are from each other, some programs use the *sum of squared distances* instead of the Euclidean distance.

Another option in some programs is replacing the squared distances with the sum of absolute differences of the coordinates. It can be formulated as follows:

$$d_{ij} = \Sigma \mid x_{ik} - x_{jk} \mid$$

This distance measure is named as the *absolute* or *city-block distance* function. Here, x_{ik} is the value of variable X_k for individual i and x_{jk} is the value of the same variable for individual j. (Aldenderfer and Blashfield, 1984) Although this measure can be used in some situations, it causes some problems. This measure assumes that there is no correlation between variables and if the variables are correlated the clusters will be not valid. Another issue is that the characteristics of variables are not always measured in same scales, which makes it impossible to use the city-block distance (Hair *et al.,* 1998).

One of the other distance measures is the *Minkowski metric*, which is defined in a general form as (Johnson and Wichern, 1998):

$$d_{ij} = \left(\Sigma \mid x_{ik} - x_{jk} \mid^{r}\right)^{1/r}$$

There are other distances and the most important of these is the *Mahalonobis D^2,* which is also called *generalized distance*. It directly incorporates Euclidean distance and a standardization procedure. This distance measure is defined as

$$d_{ij} = (x_i - x_j)' [\Sigma (x_i - x_j)]^{-1}$$

where (‘) indicates the transpose.

As mentioned above, Mahalanobis D^2 incorporates correlations among variables by the inclusion of the variance-covariance matrix. When the correlation between variables is zero, Mahalanobis D^2 is equivalent to squared Euclidean distance.

Although many situations are appropriate for use of the Mahalanobis distance, not all computer programs include it as a measure of similarity. In such cases, the researcher usually selects the squared Euclidean distance.

5.1.2. Clustering Algorithms

After defining the similarity measures, the second major question to answer is about the procedure being used to place similar objects into groups. Hundreds of computer programs use different algorithms to answer this question.
Seven major families of clustering methods have been developed:

a. Hierarchical agglomerative
b. Hierarchical divisive
c. Iterative partitioning
d. Density search
e. Factor analytic
f. Clumping
g. Graph theoretic

The difference of these families comes from their different perspective of creating groups of variables. Before discussing each procedure the following issues should be mentioned: Although there are many algorithms, there is no generally accepted '*best*' method. Unfortunately, different algorithms can give different results on the same data set. There is usually rather a large subjective component in the assessment of the results from any particular method.

5.1.2.1. Hierarchical clustering procedures

These methods are the most used methods among the listed 7 families. Hierarchical procedures construct a tree-like structure. As mentioned before, there are basically two types of hierarchical clustering procedures:

Agglomerative methods start with each observation as one cluster and then aggregate the closest two clusters in the following step. By using this type of clustering methods, number of clusters is reduced by one at each step. At the end, all individuals are grouped into one large cluster.

When clustering algorithms work in the opposite direction of agglomerative methods, they are named as *divisive methods*. Algorithm begins with all observations in one large cluster and in the following steps the most dissimilar objects are put in the new smaller clusters. Algorithm stops when each observation is an individual cluster.

The most popular agglomerative algorithms are single linkage, average linkage, complete linkage, Ward's method and centroid method.

A. Single linkage

This procedure is the easiest method to understand and it works on the basis of minimum distance. Each case begins as a cluster and the process starts by searching the most similar entities in the matrix. The cases with the highest similarity (A and B) are merged to form the nucleus of a larger cluster. The next case (C) to be merged with this first cluster is one with the highest similarity coefficient to either A or B. In the next step, the case with the highest similarity to A, B or C is merged to the cluster and the process continues until all cases are in one large cluster (Field, 2000).

Because this procedure is hierarchical, the results will depend on the two cases that will be chosen as starting point. Another issue is that cases in a cluster need only resemble one other case in the cluster, therefore over a series of selections a great deal of dissimilarity between cases can be introduced.

B. Complete linkage

This method is similar to the single linkage, but as seen from linkage rule, it is the logical opposite of single linkage clustering. Because clustering criterion is maximum distance, this procedure is sometimes also called as farthest-neighbor approach. To include a potential case to an existing cluster it must have a certain similarity to all members of that cluster.

C. Average linkage

As explained before, another clustering algorithms such as single linkage or complete linkage use the extreme points as clustering criterion. Average linkage method starts the same as the other two methods, but combining two existing clusters is based on average distance from all individuals in one cluster to all individuals in the other cluster.

Computing the average distance can be different from one researcher to another, the most commonly used variant of average linkage uses the arithmetic average of distances among the cases. There are also different versions such as computing the distance between centroids of two clusters etc.

D. Ward's method

This method is designed to optimize the minimum variance within clusters. Cases are added into clusters while minimizing the variance within that cluster. This objective function is also known as the within-groups sum of squares or the error sum of squares (Aldenderfer and Blashfield, 1984). If x_i shows the score of i^{th} case, the error sum of squares can be calculated as follows:

$$ESS = (x_i)^2 - 1 / n (\sum x_i)^2$$

Algorithm starts with each case as one cluster. (ESS = 0) The algorithm joins existing clusters or cases that result the minimum increase in the ESS.

E. Centroid method

Centroid of a cluster is the mean value of cases on the variables in that cluster. Centroid method uses the distance between centroids of clusters as the distance between those two clusters. By using this method, every time a new case is added to an existing cluster, a new centroid is computed.

5.2. Application of Cluster Analysis

The aim of cluster analysis as applied here is to try to group companies according to their answers to the questions of competitive priorities and manufacturing objectives. Cluster analysis brings individual companies displaying similar characteristics into a number of groups together. After getting the clusters the second aim is to link the characteristics of the companies to their selections about manufacturing strategy and to determine the current position of Turkish machine manufacturing industry.

Classification is made in two steps. As in factor analysis, the first step was grouping of companies according to given relative importance to listed 12 competitive priorities, which is followed by clustering of companies according to their answers to manufacturing objectives.

Agglomerative hierarchical clustering algorithms are selected as method and Ward's method is applied because of its nature of optimizing within cluster variances. Squared Euclidean distance is used as the distance measure. The procedure is applied to different data sets many times and the results are listed in the following pages.

Second step was the determination of the differences between the clusters. One of the multivariate data analysis methods, MANOVA is used to test the differences between the population means. To obtain exactly which answers are different, a pairwise comparison of means between groups is conducted and the differences are listed.

Last step was listing of results and interpretation of groupings.

5.3. Results

5.3.1. Cluster Analysis Results for Competitive Priorities

First Attempt:

As the starting point to clustering, companies were grouped according to their respective answers to 12 competitive priorities. Three competitive priorities; 'niche market', 'widespread delivery' and 'a broad product line' were discarded from factor analysis because of negative impact of their low mean importance values. It is considered to be consistent to discard these variables also in this analysis.

As illustrated with a dendrogram in Appendix L, 37 companies are grouped into 5 clusters. These clusters are designated using numbers and designations are shortened in the following tables and text as CL1, CL2, CL3, CL4 and CL5. Each group consists of 4, 9, 9, 8 and 7 companies respectively.

Mean and standard deviation of responses to competitive priorities are summarized in Table 5.1. Competitive priorities are listed in the same order as they are grouped after factor analysis. Some general statistics about ranking of clusters might be useful. (Table 5.2) The following table is prepared using Table 5.1. Numbers in each cell show how many times a cluster is ranked as the number in the first column according to mean importance. It can be easily interpreted that CL1 has for almost all questions the best ranking, in other words they have evaluated most of the competitive priorities as important. Generally, CL 2 ranked as the second cluster, which is followed by CL 4 and CL 3. CL 5 ranked for most of the questions in the list of the last two clusters.

Table 5.1. Comparison of clusters according to 12 competitive priorities

COMPETITIVE PRIORITIES	***CLUSTER***									
	CL1		***CL2***		***CL3***		***CL4***		***CL5***	
	Mean	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*
Customize on special products	5,00	0,000	4,56	0,527	4,56	0,726	4,00	1,069	3,29	0,488
High performance products	5,00	0,000	3,89	0,601	4,33	0,707	4,25	0,707	2,57	0,535
Durable goods	4,75	0,500	4,00	0,707	3,89	0,782	4,37	0,744	3,43	0,976
Consistent quality level	5,00	0,000	5,00	0,000	4,00	0,500	4,88	0,354	3,14	0,690
Reliable products	5,00	0,000	4,11	0,782	4,44	0,527	4,75	0,463	3,86	0,690
Rapid design change / new pr.inv.	4,25	0,957	4,22	0,441	2,78	0,833	3,38	0,518	3,86	0,900
Rapid deliveries	4,25	0,500	4,00	0,707	3,33	0,500	4,00	0,756	3,86	1,215
Rapid adoption to volume changes	5,00	0,000	3,56	1,130	2,67	0,500	3,38	0,518	3,00	1,155
Dependable deliveries	3,75	1,500	4,44	0,726	3,56	0,527	4,50	0,535	3,57	0,976
After sales service	5,00	0,000	4,89	0,333	3,89	0,782	3,00	1,195	3,86	0,690
Brand image	5,00	0,000	4,67	0,500	4,11	0,333	3,13	0,991	3,29	0,488
Low price	5,00	0,000	2,78	0,972	3,89	0,601	3,87	0,991	2,86	0,690
Number of companies	*4*		*9*		*9*		*8*		*7*	

Table 5.2. Ranking of clusters

	CLUSTER				
	CL1	***CL2***	***CL3***	***CL4***	***CL5***
#1	11	1	-	1	-
#2	-	7	3	4	-
#3	1	1	4	3	1
#4	-	2	1	2	7
#5	-	1	4	2	4

In order to find differences between clusters, two different approaches are used. First approach is comparing the answers to a particular question in light of MANOVA and trying to find out which questions differ between pairs of clusters. Differences are listed as the following:

- CL1 has statistically significant different values for question ‘low price’. Companies belonging to this cluster have evaluated low price with less importance then companies in all other clusters.
- CL3 differs with its given importance to ‘consistent quality level’. They evaluated quality with less importance than companies in Cluster 1, 2 and 4; but more important than companies in Cluster 5.
- CL5 companies also differ from all members of other clusters according to their answers of ‘consistent quality level’. Cluster 5 has evaluated this competitive priority with strongly less importance than other clusters.
- Companies in CL4 evaluated ‘after sales service’ with strongly less importance than companies in clusters 1 and 2, with less importance than companies in CL3 and CL5.
- CL5 companies differ with their answers to ‘high performance products’. Difference between CL5 and CL1 is strong, mean difference between CL5 and other clusters show not such strength. CL5 gives minimum importance to this competitive priority among all clusters.

Table 5.3. Comparison of competitive priorities factor means between clusters

	Cluster	Mean	Std. Dev.	Number of companies
Factor Mean 1	CL1	4,95	0,100	4
	CL2	4,31	0,333	9
	CL3	4,24	0,410	9
	CL4	4,45	0,510	8
	CL5	3,26	0,341	7
	Total	4,19	0,621	37
Factor Mean 2	CL1	4,31	0,554	4
	CL2	4,06	0,542	9
	CL3	3,08	0,217	9
	CL4	3,81	0,320	8
	CL5	3,57	0,773	7
	Total	3,70	0,629	37
Factor Mean 3	CL1	4,31	0,774	4
	CL2	3,88	0,382	9
	CL3	3,29	0,551	9
	CL4	2,75	0,886	8
	CL5	3,18	0,703	7
	Total	3,41	0,801	37
Factor Mean 4	CL1	5,00	0,000	4
	CL2	2,78	0,972	9
	CL3	3,89	0,601	9
	CL4	3,88	0,991	8
	CL5	2,86	0,690	7
	Total	3,54	1,043	37

The second attempt to show the difference of clusters is comparison of mean answers to the particular questions in a component that is found by analyzing 12 competitive priorities. Mean and standard deviations of questions for each cluster are shown in Table 5.3. *Factor Mean 1* is average of 5 questions in component named 'product', where *Factor Mean 2* is the average of 4 questions grouped as 'responsiveness'. *Factor Mean 3* consists of the average value for questions in component 'company image'. The last component, 'price', builds *Factor Mean 4*.

Table 5.4 summarizes the results of pairwise comparison of factor means between clusters. Instead of listing the mean differences of clusters or significance values, plus and minus signs are used in order to get the wanted impact easier. Clusters in rows are compared with clusters in columns for each factor mean and results are listed in the cells.

If a cell is empty, it means that there is no significant difference between factor means of these clusters. Double plus indicates a strong positive difference between factor means, with significance level lower than 0,01. Single plus shows positive difference with significance level 0,05. Double minus represents a strong negative difference at 0,01 significance level, where single minus shows negative difference at 0,05 significance level. It is also obvious that the matrix is negatively symmetric, i.e., values in the upper diagonal and in the lower diagonal have opposite signs.

Some factors differentiate clusters strongly from all other clusters. *Factor Mean 1*, representing mean value of variables related with product, differentiates CL1 and CL5 from all other clusters. In other words, CL1 evaluated gaining competitive advantage with the properties of their product more important than all other clusters and CL5 evaluated it less important than all other clusters. Also *Factor Mean 4*, representing 'low price' as a competitive priority differentiates CL1 distinctly from all other clusters. Companies in CL1 give more importance to 'low price' than all other companies.

Table 5.4. Differences of clusters according competitive priorities factor means

		CL1	***CL2***	***CL3***	***CL4***	***CL5***
CL1	FM1		+	+ +	+	+ +
	FM2			+ +		+
	FM3			+	+ +	+
	FM4		+ +	+	+	+ +
CL2	FM1	-				+ +
	FM2			+ +		
	FM3				+ +	+
	FM4	- -		- -	- -	
CL3	FM1	- -				+ +
	FM2	- -	- -		- -	
	FM3	-				
	FM4	-	+ +			+
CL4	FM1	-				+ +
	FM2			+ +		
	FM3	- -	- -			
	FM4	-	+			+
CL5	FM1	- -	- -	- -	- -	
	FM2	-				
	FM3	-	-			
	FM4	- -		-	-	

All clusters have 16 items to compare with other clusters. In other words, a cluster's factor means for 4 factors are compared with means of remaining 4 clusters. CL1 has 13 statistically different means for 13 items out of these 16 comparisons. CL5 follows it with 10 differences, where CL2, CL3 and CL4 have 8, 9 and 8 different items respectively. It can be stated that interpreting the characteristics CL1 and CL5 are easier than other clusters.

Companies in CL1 give great emphasis on competing through their product. The second competitive priority, 'low price' also differentiates these companies strongly from other clusters. They also consider 'Company image' as an important competitive priority. It can be stated that these companies are highly competitive and dynamic, which want to expand their target market segment and increase their market share against their rivals.

CL2 companies have lower mean values for competitive priority ‘low price’, but the standard deviation of *Factor Mean 4* (low price) is very close to 1. These companies give more importance to the second factor, which is named as responsiveness. Variables in this factor are ‘rapid design change/new product innovation’, ‘rapid deliveries’, ‘rapid adoption to volume changes’ and ‘dependable deliveries’. They are all related with customer relations and customer care, thus CL2 can be represented with their given importance to customers. High standard deviation for ‘low price’ shows that some companies want to support customer satisfaction with low prices, while others do not.

In contrast to CL2, CL3 basically differentiates itself with its low mean values for responsiveness. Price based competition is not as much important as companies in CL1, but they get the second highest score for this factor. (Table 5.5) Competitive strategy for this group of companies can be described as pure price based strategy.

Companies in CL4 evaluate competitive priority factor ‘product’ with respectively higher importance than companies in other clusters. They give statistically significant high importance to ‘responsiveness’ than CL3, which competes with low prices and statistically significant less importance to company image than CL2, which competes with strong customer relations. Their strategy can be seen as a hybrid strategy of pure price and pure customer based strategies.

CL5 has lower values than all clusters for all factor means. Product is evaluated as the least important competitive priority. Companies in this group also give less importance to price. It makes us think about the customer profile of these companies. It gives the impression that their customers are ready to buy their products at every quality and every level of price. If we look at the companies in this group, our hypothesis is confirmed, because most of these companies produce special equipment like laboratory equipment or industrial washing machines.

Table 5.5. Competitive priorities summary table

More İmportant

<table>
<tr><th>Rank</th><th>PRODUCT</th><th>RESPONSIVENESS</th><th>COMPANY IMAGE</th><th>PRICE</th></tr>
<tr><td>1.</td><td>CL1</td><td>CL1</td><td>CL1</td><td>CL1</td></tr>
<tr><td>2.</td><td>CL4</td><td>CL2</td><td>CL2</td><td>CL3</td></tr>
<tr><td>3.</td><td rowspan="2">CL3 – CL2</td><td>CL4</td><td>CL3</td><td>CL4</td></tr>
<tr><td>4.</td><td>CL5</td><td>CL5</td><td>CL5</td></tr>
<tr><td>5.</td><td>CL5</td><td>CL4</td><td>CL4</td><td>CL2</td></tr>
</table>

Less important

5.3.2. Cluster Analysis Results for Manufacturing Objectives

The same approach as used in competitive priorities' cluster analysis is used to reveal the differences among clusters according to manufacturing objectives. Companies are grouped according to their answers to 14 manufacturing objectives using Ward's method. Five clusters are formed from 40 companies and these clusters are named using numbers from 1 to 5. (Appendix M) First cluster consists of 13 companies; second cluster consists of 7 companies. Clusters 3, 4 and 5 have 5, 6 and 9 companies, respectively.

An important point is the difference of cluster members from the previous analysis. The reader must be careful not to compare the clusters having the same name as the clusters in the analysis of competitive priorities.

Mean and standard deviation of each variable for each cluster is calculated and results are represented in Table 5.6. In order to make the comparison easier, manufacturing objectives are listed in the same order as they are listed after factor analysis. According to this distribution, CL3 has the lowest scores for almost all of the manufacturing objectives, where CL4 and CL5 have the best or second best score for most of the variables. Table 5.7 gives a summary of the rankings of clusters. Numbers in the cells indicate how many times that cluster had this ranking.

Table 5.6. Comparison of clusters according to 14 manufacturing objectives

MANUFACTURING OBJECTIVES	***CLUSTER***									
	CL1		***CL2***		***CL3***		***CL4***		***CL5***	
	Mean	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*
Increase conformance quality	4,00	0,707	4,14	1,069	3,80	0,837	4,50	0,837	4,44	0,726
Increase direct labor productivity	4,23	0,439	3,43	0,787	4,20	0,447	4,67	0,516	4,78	0,441
Decrease unit cost	3,85	0,801	4,14	1,069	3,40	0,548	4,33	0,516	5,00	0,000
Reduce break-even points	3,92	0,760	3,00	0,577	3,00	0,707	4,83	0,408	4,22	0,833
Increase production rate	4,00	0,707	3,43	0,535	3,40	0,548	4,50	0,548	4,67	0,500
Decrease production flow time	3,46	0,660	3,14	0,378	2,60	0,548	4,83	0,408	4,44	0,726
Decrease new product dev. time	3,62	0,768	3,43	0,535	2,20	0,447	4,17	0,408	3,33	1,118
Decrease new product intr. time	3,38	0,650	3,00	0,577	1,80	0,447	4,17	0,408	3,56	1,014
Decrease breakdowns and stops	4,00	0,707	3,43	0,787	3,20	0,837	2,50	1,049	3,89	0,782
Reduce setup/changeover times	3,31	0,630	3,29	0,756	2,80	0,837	3,00	0,632	4,44	0,726
Reduce production lead time	3,92	0,760	3,57	0,535	2,80	0,447	3,83	0,983	4,44	0,527
Increase delivery reliability	3,77	0,599	3,43	0,787	2,40	0,548	4,00	0,632	4,00	0,707
Producing high value added prod.	3,23	0,927	4,43	0,787	3,00	0,707	4,33	0,516	4,56	0,527
Increase market share	4,54	0,519	5,00	0,000	3,60	1,517	5,00	0,000	4,56	0,726
Number of companies	*13*		*7*		*5*		*6*		*9*	

Table 5.7. Ranking of clusters

	CLUSTER				
	CL1	***CL2***	***CL3***	***CL4***	***CL5***
#1	1	1	-	7	7
#2	2	1	-	4	5
#3	7	5	-	1	1
#4	4	6	3	1	1
#5	-	1	11	1	-

First Attempt:

By comparing the responses for the manufacturing objectives using MANOVA, these following conclusions have been reached:

- CL2 differs from all other clusters with its significantly low values for 'increasing direct labor productivity'.
- CL3, which has the lowest scores for almost all manufacturing objectives, differentiates from all other clusters with its significantly low scores for 'decreasing new product development time', 'decreasing new product introduction time', 'increasing delivery reliability' and 'increasing market share'.
- CL5 has evaluated 'reducing setup times' with significantly high scores than all other clusters.

Second Attempt:

Since this type of comparison did not provide much data about differences of cluster profiles, second attempt is made. Clusters are compared using mean values for the variables belonging to a factor.

Factor means for each cluster and the corresponding standard deviations are given in Table 5.8. Factor mean 5 has the highest average scores. This group of objectives, representing the manufacturing objectives to positioning the company in the market, is evaluated as the most important manufacturing objectives. 'Manufacturing objectives to decrease production cost' are ranked as the second important manufacturing objectives.

Table 5.8. Comparison of manufacturing objectives factor means between clusters

	Cluster	**Mean**	**Std. Dev.**	**Number of Companies**
Factor Mean 1	CL1	4,00	0,489	13
	CL2	3,68	0,746	7
	CL3	3,60	0,454	5
	CL4	4,58	0,341	6
	CL5	4,61	0,282	9
	Total	4,12	0,612	40
Factor Mean 2	CL1	3,73	0,483	13
	CL2	3,29	0,393	7
	CL3	3,00	0,353	5
	CL4	4,67	0,258	6
	CL5	4,56	0,583	9
	Total	3,89	0,747	40
Factor Mean 3	CL1	3,50	0,677	13
	CL2	3,21	0,393	7
	CL3	2,00	0,354	5
	CL4	4,17	0,408	6
	CL5	3,44	1,044	9
	Total	3,35	0,879	40
Factor Mean 4	CL1	3,75	0,408	13
	CL2	3,43	0,374	7
	CL3	2,80	0,481	5
	CL4	3,33	0,665	6
	CL5	4,19	0,464	9
	Total	3,61	0,620	40
Factor Mean 5	CL1	3,88	0,506	13
	CL2	4,71	0,393	7
	CL3	3,30	0,837	5
	CL4	4,67	0,258	6
	CL5	4,56	0,583	9
	Total	4,23	0,707	40

Table 5.9. Differences of clusters according to manufacturing objectives factor means

		CL1	*CL2*	*CL3*	*CL4*	*CL5*
CL1	FM1				-	- -
	FM2		+	+ +	- -	- -
	FM3			+ +		
	FM4			+ +		-
	FM5		- -	-	- -	- -
CL2	FM1				- -	- -
	FM2	-			- -	- -
	FM3			+ +	-	
	FM4			+		- -
	FM5	+ +		+ +		
CL3	FM1				- -	- -
	FM2	- -			- -	- -
	FM3	- -	- -		- -	- -
	FM4	- -	-			- -
	FM5	-	- -		- -	- -
CL4	FM1	+	+ +	+ +		
	FM2	+ +	+ +	+ +		
	FM3		+	+ +		
	FM4					- -
	FM5	+ +		+ +		
CL5	FM1	+ +	+ +	+ +		
	FM2	+ +	+ +	+ +		
	FM3			+ +		
	FM4	+	+ +	+ +	+ +	
	FM5	+ +		+ +		

Pairwise comparison of clusters is summarized using plus and minus signs in Table 5.9. As previously explained, double plus indicates a positive difference between cluster means at 0,01 significance level, where single plus indicates positive difference at 0,05 significance level. The same classification is also valid for negative differences; they are expressed using single and double minus signs.

Each cluster is compared in 5 different factors with remaining 4 clusters. So, each cluster has 20 items to be compared with others. CL3 has 16 different items from other clusters; CL1 and CL5 follow it with 13 different items. CL2 and CL4 have only 11 different items.

Companies in CL1 are statistically different respect to their answers to 'increase production rate' and factor 5; 'positioning the company in the market'. They give relatively less importance to manufacturing objectives for positioning their company.

CL2 gives less importance to manufacturing objectives related to increasing production rate. The most important manufacturing objective factor for this group of companies is manufacturing objectives about positioning the company in the market.

Companies in CL3 differentiate with their answers to manufacturing objectives about new product development. They give a strong negative importance to these objectives than all the other clusters. Also 'positioning the company in the market' is not strongly positive evaluated. It gives the idea of classifying these companies as traditional manufacturers.

CL4 evaluated most of the manufacturing objectives as important. The least important manufacturing objectives for this group of companies are 'Decrease breakdowns and stops' and 'reduce changeover / setup times'. For all the other manufacturing objectives they ranked in the list of first two clusters.

CL5 is another cluster that evaluated most of the manufacturing objectives as important. They are strongly dominant for manufacturing objectives 'to improve processes', 'to increase production rate' and 'to decrease production cost'. They give great emphasis to some manufacturing objectives and try to control manufacturing continuously. In comparison to other clusters, CL5 has an extremely high standard deviation for factor mean 3, representing manufacturing objectives to new product development.

5.3.3. Analysis of Competitive Priority Clusters according to Manufacturing Objectives

We kept the clusters found by analyzing competitive priorities fix. Analysis of manufacturing objectives is made using this grouping. The aim of this type of analysis is to find some relationships between competitive priorities and manufacturing objectives.

As done in previous analyses, MANOVA is used to compare factor means of cluster pairs. Results are given in Table 5.10.

At the end of clustering of the companies according to competitive priorities, CL1 companies were differentiated with their given importance to ‘product’, ‘low price’ and ‘company image’. These companies evaluated most of the manufacturing objectives with more importance than companies in other clusters. (Table 5.10) But especially high scores are given to manufacturing objectives ‘decrease production cost’, ‘increase production rate’ and ‘improve processes’.

This result is completely consistent with the companies’ competitive priorities. In other words, these companies have selected the right manufacturing objectives to compete with their product and price. Table 5.11 summarizes the results of pairwise comparison of clusters. Double and single plus or minus signs are used to emphasize the significance level.

CL1 dominates CL2 in *Factor Mean 2* and *Factor Mean 4.* This means, CL1 gives more importance to manufacturing objectives for increasing production rate and improving processes. This result also approves our interpretation about their competitive strategies. CL2 companies differentiate with their given importance to ‘customer response’ as a competitive priority, ‘low prices’ is not an important competitive priority for them. Thus, as visible in Table 5.10, the most important manufacturing objective for companies in CL2 is ‘positioning the company in the market’.

Table 5.10. Descriptive statistics for manufacturing objectives factor means

	Cluster	Mean	Std. Deviation	Number of Companies
Factor Mean 1	A	4,56	0,591	4
	B	4,00	0,781	9
	C	4,17	0,573	9
	D	4,21	0,443	7
	E	3,82	0,607	7
	Total	4,11	0,622	36
Factor Mean 2	A	4,75	0,500	4
	B	3,67	0,559	9
	C	3,94	0,846	9
	D	4,21	0,636	7
	E	3,64	0,802	7
	Total	3,96	0,750	36
Factor Mean 3	A	4,00	1,414	4
	B	3,44	0,682	9
	C	3,89	0,651	9
	D	3,14	0,852	7
	E	2,86	0,627	7
	Total	3,44	0,860	36
Factor Mean 4	A	4,38	0,479	4
	B	3,67	0,500	9
	C	3,39	0,588	9
	D	3,79	0,509	7
	E	3,29	0,699	7
	Total	3,63	0,625	36
Factor Mean 5	A	4,38	0,479	4
	B	4,39	0,601	9
	C	4,33	0,559	9
	D	4,36	0,627	7
	E	3,93	0,976	7
	Total	4,28	0,659	36

Table 5.11. Pairwise comparison of manufacturing objectives*

		CL1	***CL2***	***CL3***	***CL4***	***CL5***
CL1	FM1					
	FM2		+			+
	FM3					+
	FM4		+	+ +		+ +
	FM5					
CL2	FM1					
	FM2	-				
	FM3					
	FM4	-				
	FM5					
CL3	FM1					
	FM2					
	FM3	- -				+
	FM4					
	FM5					
CL4	FM1					
	FM2					
	FM3					
	FM4					
	FM5					
CL5	FM1					
	FM2	-				
	FM3	-		-		
	FM4	- -				
	FM5					

* (+ +) or (- -) indicate a statistically significant difference at 0,01 level, where (+) or (-) indicate a statistically significant difference at 0,05 level.

Table 5.12. Manufacturing objectives summary table

More İmp. → Less Imp.

Rank	Decr. Pr. Cost	Incr. Pr. Rate	New pr. Devlp.	Impr. Procs.	Pos. In mar.
1.	CL1	CL1	CL1	CL1	CL2
2.	CL4	CL4	CL3	CL4	CL1
3.	CL3	CL3	CL2	CL2	CL4
4.	CL2	CL2	CL4	CL3	CL3
5.	CL5	CL5	CL5	CL5	CL5

Companies in CL1 and CL3 significantly differentiate from each other with evaluation of manufacturing objectives to improve processes. CL1 dominates CL3 for this item. If we go back to their competitive priorities; it is obvious that CL1 gives more importance to ‘low price’ than CL3. Improving processes is a supporting manufacturing objective of low price. So, this result is also reflects the current position of the clusters.

CL1 strongly dominates CL5 with its answers to manufacturing objectives related to ‘increasing production rate’, ‘new product development’ and ‘improving processes’. CL5 companies were classified with their special products and absence of their substitutes. CL5 companies evaluated almost all competitive priorities with least importance, the same pattern is also visible for their manufacturing objectives. For all factor means they ranked as the last cluster.

CL3 has also statistically different positive difference from CL5. CL3 companies, which base their competitive advantage to pure price strategy, have evaluated new product development related manufacturing objectives as more important than CL5 companies. It is not because of extremely high scores of CL3, it is because CL5 companies have assigned to these manufacturing objectives with low values. Mean factor score of CL5 for new product related manufacturing objectives is 2,86. This is the minimum mean score of all clusters for all factors.

5.4. Summary

In this chapter, companies are grouped into clusters according to their responses to given competitive priorities and manufacturing objectives. The distance measure is selected to be the squared Euclidean distance. Ward's Method is applied as the clustering algorithm.

In the case of competitive priorities, companies are grouped into clusters according to their responses to 12 competitive priorities that were used in factor analysis. Five different company clusters are formed with 4,9,9,8 and 7 companies in each cluster.

One of the multivariate data analysis methods, MANOVA is used to determine the differences between different clusters. Mean scores of the variables in the factors are used to determine the differences. CL1 is differentiated from other clusters with the importance it attaches to the factors 'product' and 'low price'. CL2 gives great importance to the factors 'responsiveness' and 'company image', which together can be designated as customer focus. CL3 is mainly focused on 'low price'. Competitive priorities of CL4 can be described as a hybrid strategy of customer focus and 'low price'. Companies in CL5 are differentiated from the others with their low scores on most of the competitive priorities. These companies produce special products, thus targeting a special customer segment.

Companies are also grouped according to their responses to manufacturing objectives. Five clusters are formed with respective number of firms being 13, 7, 5, 6 and 9. Fourteen manufacturing objectives are grouped under 5 factors and factor means are used to expose the differences between company clusters.

CL1 companies differentiate themselves with the factor 'production efficiency', CL2 companies give more importance to manufacturing objectives for 'positioning the company in the market'. Companies in CL3 intensify on the factor 'new product development and introduction'. CL4 and CL5 companies have evaluated most of the manufacturing objectives as important. CL5 companies display a strong dominance over the other companies in their emphasis on the factors ‘process improvement’, ‘increasing production efficiency’ and ‘decreasing production cost’.

In the last section of the chapter, an answer is sought for the question of how consistent the companies are in choosing their manufacturing objectives for a set of competitive priorities. For that purpose, clusters achieved by analyzing competitive priorities are fixed and mean values of the questions in 5 factors of manufacturing objectives are used to determine statistically significant differences between these clusters. Results indicate to a certain level of consistency.

6. CONCLUSION

Global manufacturing is in a state of transition and restructuring. In the changing environment of technology, economic competition is also changing accordingly in a rapid pace. Competition is not static anymore and successes or failures do not only depend on production factors. Competitive strategies are developed to determine how the business is going to compete, what its goals should be and what policies will be needed to carry out these goals. Manufacturing should not only be considered as a technical function, but as a major contributor to company competitiveness

In order to conduct strategic planning for manufacturing it is necessary to have a planning process. Kim and Arnold (1996) introduced a way for manufacturing strategy operationalization. They proposed a 3-step model, which links competitive priorities of a manufacturing firm with internal consistency to strategic tasks and action plans.

In this study, the conceptual model proposed by Kim and Arnold (1996) has been employed. Based upon a sample of 41 companies, manufacturing strategies in Turkish machine manufacturing industry have been investigated. A questionnaire form consisting of 9 sections and 543 data items is used to get data about the current position of the machine manufacturing industry in Turkey.

General company profiles are determined. Results are compared with the results of former studies in different countries and with the results of different sectors in the Turkish manufacturing industry. As we see from the number of firms applying a particular strategy and from the mean importance attached to components of manufacturing strategy, new trends seem to be popular for the companies operating in this sector.

Importance of the given competitive priorities for the next two years, importance of the given manufacturing objectives for the next two years and the emphasis of the employed action plans during the past two years have been evaluated by the companies. Three different data sets are formed and factor analysis is applied to each different data set. The aim of this study was is to group the variables in order to reduce the number of variables and explain the same data set with smaller number of components. It has been found that reducing the variables resulted in better groupings. Variables with relatively small mean values have been discarded from data matrices and factor analyses are applied several times to each data set.

After finishing factor analysis, the second aim of the study was to group the companies according to manufacturing strategies they applied. The same data sets consisting of competitive priorities and manufacturing objectives are used for this purpose. Cluster analysis is employed for each data set. Companies are grouped in 5 clusters according to their responses to competitive priorities. The differences between groups are determined using multivariate data analysis methods. Mean scores of the variables in each component are used to determine a statistically significant difference between means of the groups. Pairwise comparisons are listed and different competitive priority strategies have been investigated.

The same procedure is also applied to manufacturing objectives. Companies are grouped into 5 clusters. Differences of the clusters are determined using the mean scores of manufacturing objectives in each component. Clusters applying different manufacturing objectives have been determined.

As the second stage of the analysis, clusters obtained based on competitive priorities have been fixed. In order to determine the differences in manufacturing objectives of different competitive priority clusters, the differences between clusters have been found by analyzing mean scores of the manufacturing objectives in 5 components. It can be stated that companies have selected the most appropriate manufacturing objectives for fulfilling their competitive priorities.

7. APPENDICES

Appendix A. Correlation matrix of 15 competitive priorities

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1	1,000														
2	0,193	1,000													
3	0,095	0,363	1,000												
4	0,391	0,536	0,303	1,000											
5	0,332	0,287	0,275	0,632	1,000										
6	0,215	0,305	0,451	0,574	0,308	1,000									
7	0,234	-0,028	-0,091	0,352	0,255	0,315	1,000								
8	0,570	0,232	0,066	0,611	0,658	0,275	0,415	1,000							
9	0,058	0,134	0,326	0,138	0,197	-0,022	0,055	0,239	1,000						
10	0,031	0,135	0,351	0,398	0,176	0,292	0,181	0,253	0,165	1,000					
11	0,480	0,237	0,504	0,539	0,313	0,485	0,344	0,320	0,366	0,256	1,000				
12	0,276	0,101	0,352	0,210	0,030	0,447	0,329	0,175	0,467	0,376	0,450	1,000			
13	0,059	0,113	0,134	0,111	-0,186	0,271	-0,026	0,004	0,348	0,157	0,429	0,497	1,000		
14	0,177	0,194	0,229	0,447	0,397	0,219	0,055	0,529	0,295	0,572	0,307	0,256	0,276	1,000	
15	0,300	0,302	0,299	0,533	0,630	0,143	0,124	0,637	0,390	0,255	0,287	0,122	0,055	0,599	1,000

Appendix B. Correlation matrix of 16 manufacturing objectives

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1,000															
2	0,478	1,000														
3	0,540	0,468	1,000													
4	0,397	0,207	0,478	1,000												
5	0,356	0,268	0,446	0,577	1,000											
6	0,432	0,196	0,577	0,383	0,570	1,000										
7	0,203	0,106	0,055	0,233	0,325	0,157	1,000									
8	0,295	0,172	0,242	0,467	0,560	0,456	0,832	1,000								
9	0,287	0,416	0,193	0,302	0,404	0,244	0,365	0,379	1,000							
10	0,195	0,280	0,275	0,272	0,341	0,436	0,174	0,335	0,445	1,000						
11	0,238	0,211	0,088	0,118	0,344	0,356	0,109	0,253	0,245	0,402	1,000					
12	0,248	0,061	-0,103	0,180	0,416	0,292	0,092	0,267	0,333	0,135	0,311	1,000				
13	0,217	-0,163	0,052	0,397	0,300	0,235	0,246	0,376	0,139	-0,095	0,309	0,347	1,000			
14	0,371	0,103	0,146	0,348	0,248	0,129	0,319	0,352	0,237	-0,072	0,238	0,356	0,767	1,000		
15	0,349	0,161	-0,016	0,266	0,187	-0,007	0,336	0,270	0,310	0,203	-0,088	0,302	-0,015	0,153	1,000	
16	0,070	0,107	-0,043	0,009	-0,146	-0,077	0,020	-0,060	0,350	0,367	0,380	0,050	0,189	0,240	0,048	1,000

Appendix C. Correlation matrix of 35 action plans

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**
1	1																																		
2	0,7680	1																																	
3	0,5430	0,5840	1																																
4	0,4520	0,4810	0,5380	1																															
5	0,3720	0,4310	0,5630	0,6070	1																														
6	0,5200	0,5420	0,6420	0,5590	0,6160	1																													
7	0,3940	0,2410	0,4190	0,2750	0,4930	0,3620	1																												
8	0,3130	0,2610	0,3100	0,5260	0,4230	0,5240	0,2910	1																											
9	0,4100	0,4070	0,3220	0,2590	0,2440	0,0860	0,1580	-0,1440	1																										
10	0,1340	0,3470	0,2950	0,2980	0,3820	0,0730	0,2780	0,0400	0,5970	1																									
11	0,1300	0,1250	0,0160	-0,1220	-0,1020	-0,0580	-0,0670	0,0710	-0,0620	0,0210	1																								
12	-0,3140	-0,0850	0,1760	-0,1200	0,0880	-0,1870	0,0610	-0,2020	-0,1630	0,1950	0,3650	1																							

Appendix C. Correlation matrix of 35 action plans (Continued)

13	-0,1310	-0,0310	0,1250	-0,0360	-0,0870	-0,1970	-0,0460	-0,0190	-0,0720	0,1840	0,2060	0,5930	1																						
14	-0,1150	0,1480	0,0320	-0,2570	-0,0620	-0,1520	-0,0880	-0,1890	-0,1520	-0,0330	0,5600	0,7060	0,3160	1																					
15	-0,0810	-0,0040	-0,0800	-0,0210	-0,0110	-0,1540	0,0400	0,1300	-0,1920	0,1430	0,4280	0,4950	0,4540	0,5720	1																				
16	-0,1160	-0,1890	-0,0390	-0,0130	0,1010	-0,2410	0,1880	0,0960	-0,1900	0,0140	0,5720	0,4120	0,1040	0,4860	0,4940	1																			
17	0,0900	0,2080	0,0260	0,1730	0,1590	0,0880	-0,1430	0,2020	-0,1860	0,0490	0,5380	0,2260	0,1790	0,4100	0,5860	0,5740	1																		
18	-0,0030	0,0800	0,3190	0,2380	0,4030	0,0990	0,1360	0,1570	-0,1090	0,2470	0,2440	0,4970	0,6590	0,2650	0,3560	0,3330	0,3930	1																	
19	-0,1500	0,0890	0,2740	0,0640	0,3240	-0,0570	0,2380	-0,0330	0,1280	0,3440	0,0730	0,5930	0,4050	0,4420	0,2390	0,2790	0,0460	0,3710	1																
20	-0,0460	0,1500	0,2520	-0,1750	-0,1630	-0,0690	0,0110	-0,0130	-0,1060	0,0780	0,2900	0,5110	0,3850	0,5530	0,3100	0,2230	0,1960	0,2130	0,2320	1															
21	-0,0320	0,1370	0,3460	-0,1410	0,1170	0,1510	0,1820	0,0800	-0,0300	0,1080	0,4140	0,5150	0,2470	0,5490	0,2610	0,2820	0,1170	0,2580	0,1990	0,6270	1														
22	-0,3520	-0,2600	-0,1900	-0,1800	-0,3530	-0,1710	-0,2410	-0,0150	-0,3190	-0,2330	0,3580	0,1760	-0,1920	0,4540	0,3150	0,3210	0,0940	-0,1540	-0,0680	0,1330	0,1710	1													
23	-0,2720	-0,2300	-0,0260	-0,1840	-0,1420	-0,2110	-0,1440	0,0900	-0,4390	-0,0200	0,4450	0,5040	0,3120	0,4120	0,4020	0,4340	0,3410	0,2940	0,1580	0,4120	0,2710	0,3820	1												
24	0,0080	-0,0510	0,2160	0,0650	0,2800	0,0700	0,0790	0,0080	-0,1370	0,1590	0,3120	0,4490	0,4160	0,2080	0,3140	0,2910	0,3880	0,5830	0,0790	0,3930	0,4030	-0,2380	0,4170	1											
25	-0,0180	0,1710	0,2980	-0,0500	0,1990	0,0710	0,1060	-0,0090	0,0560	0,3120	0,4480	0,5320	0,3100	0,6130	0,4410	0,5060	0,4060	0,3640	0,2640	0,6260	0,7020	0,1480	0,4300	0,4550	1										

Appendix C. Correlation matrix of 35 action plans (continued)

26	-0,0530	0,0870	0,2010	-0,0190	0,0990	-0,1720	0,0800	0,0560	-0,0460	0,2620	0,3330	0,6600	0,5370	0,5400	0,5740	0,5150	0,3790	0,4350	0,3240	0,5200	0,3450	0,1450	0,5750	0,3830	0,6540	1									
27	-0,0920	0,0200	0,0430	-0,1480	-0,0390	-0,1500	-0,0350	0,2270	-0,1570	0,0510	0,5380	0,5810	0,4960	0,5530	0,6070	0,4420	0,4550	0,3220	0,2180	0,4340	0,4160	0,2530	0,6770	0,2940	0,4740	0,7870	1								
28	-0,1840	0,0250	0,2120	-0,0160	0,0110	-0,1540	0,0360	0,2000	-0,1290	0,2110	0,3730	0,5710	0,3390	0,5130	0,5080	0,4390	0,2220	0,3170	0,3970	0,5970	0,5890	0,3330	0,5850	0,3310	0,5780	0,5490	0,5690	1							
29	-0,0430	0,0780	0,2640	-0,1060	0,0900	0,0910	-0,0070	0,0280	-0,0440	0,1760	0,3920	0,3460	0,3060	0,3950	0,3060	0,2030	0,1520	0,3630	0,0760	0,4040	0,5870	0,2930	0,3010	0,4000	0,6160	0,4530	0,4530	0,4960	1						
30	-0,2340	0,0490	0,1160	-0,1530	0,0960	0,0220	0,0100	0,0530	-0,2930	0,0040	0,4650	0,5780	0,2980	0,6290	0,2360	0,3300	0,2500	0,4050	0,2040	0,6590	0,7230	0,2450	0,3120	0,4410	0,6140	0,3880	0,4110	0,5330	0,6050	1					
31	-0,1760	-0,0730	0,0990	-0,2550	-0,2560	-0,1580	-0,0920	0,0020	-0,2290	-0,0610	0,4790	0,5400	0,3290	0,5620	0,4020	0,4020	0,1660	0,2400	0,1490	0,7480	0,5900	0,4470	0,4690	0,2160	0,5660	0,4960	0,5340	0,6360	0,5240	0,6080	1				
32	-0,3390	0,0680	0,1600	0,0440	0,1980	0,0830	-0,0360	0,0970	-0,2670	0,1730	0,1090	0,5970	0,4590	0,5700	0,4290	0,3110	0,2770	0,5240	0,4500	0,4520	0,4600	0,2190	0,3230	0,1690	0,6120	0,5120	0,3490	0,5270	0,3920	0,5800	0,4930	1			
33	-0,0740	-0,1000	0,4330	0,2620	0,3010	0,2680	0,2350	0,0570	-0,0810	0,1130	0,2760	0,3340	-0,0060	0,1630	0,1020	0,4860	0,2330	0,3960	0,1280	0,1640	0,3140	0,3720	0,3240	0,2310	0,4290	0,2940	0,1650	0,2310	0,3680	0,3080	0,4130	0,3300	1		
34	0,0720	0,1680	0,0810	0,1040	0,1250	-0,0220	-0,1130	0,0280	-0,1230	0,1010	0,2110	0,4340	0,4420	0,3380	0,4970	0,0340	0,2370	0,3520	0,0320	0,2120	0,1630	0,0610	0,2900	0,5130	0,1340	0,4920	0,4160	0,3250	0,2850	0,2590	0,1150	0,2060	-0,0610	1	
35	-0,0740	0,2470	0,2010	0,0840	0,1760	0,2360	0,1110	0,1770	-0,2130	0,1980	0,2200	0,4110	0,2550	0,3030	0,3990	0,0030	0,3250	0,2320	0,0940	0,3810	0,4620	0,0740	0,2920	0,4850	0,2290	0,3080	0,4400	0,3790	0,4090	0,4530	0,2120	0,3020	0,0860	0,6130	1

Appendix D. Unrotated component matrix of 15 competitive priorities

	Component				
	1	**2**	**3**	**4**	**5**
Consistent quality level	0,8170	-0,2378	0,1096	-0,2500	-0,0845
High performance products	0,7276	-0,4730	0,0712	0,2944	0,0302
Rapid adoption to volume changes	0,7156	0,3107	0,2501	-0,0381	0,2359
Customize on special products	0,6895	-0,3449	-0,4045	0,1661	0,1097
Durable goods	0,6648	-0,5345	-0,0849	-0,0665	0,0555
Brand image	0,6563	-0,0379	-0,4312	0,2443	-0,3218
Rapid deliveries	0,6061	0,2232	0,3801	-0,4231	-0,2072
Rapid design change / New product innovation	0,5263	0,3454	-0,2524	-0,4779	0,0850
Reliable products	0,5219	-0,2129	0,3843	0,1424	0,4050
A broad product line	0,4422	0,3468	-0,3834	0,3958	0,3519
Niche market	0,3101	0,6963	-0,0277	0,1892	0,1354
Widespread delivery	0,5302	0,6164	0,2064	0,2300	-0,0262
Low price	0,3962	-0,1185	0,6466	0,2956	-0,2420
Dependable deliveries	0,4729	-0,0563	-0,1637	-0,5617	0,2352
After sales service	0,5228	0,2021	-0,2107	0,0251	-0,6743

Appendix E. Unrotated component matrix of 12 competitive priorities

	Component			
	1	**2**	**3**	**4**
Consistent quality level	0,8597	0,0260	0,0961	-0,0552
High performance products	0,7795	-0,4835	-0,0716	0,0219
Customize on special products	0,7173	-0,2553	-0,3952	-0,1999
Durable goods	0,6783	-0,1904	-0,1423	-0,1504
Brand image	0,6636	-0,0149	-0,5384	0,2191
Rapid adoption to volume changes	0,6430	0,3054	0,3643	0,1119
Rapid deliveries	0,5942	0,3682	0,4438	0,1068
Reliable products	0,5469	-0,3820	0,3189	-0,1960
Rapid design change / New product innovation	0,4591	0,7284	-0,0374	-0,1444
Low price	0,3923	-0,3620	0,5123	0,4794
Dependable deliveries	0,5033	0,2191	0,0730	-0,5801
After sales service	0,4866	0,3449	-0,3749	0,5597

Appendix F. Unrotated component matrix of 14 manufacturing objectives

	Component				
	1	**2**	**3**	**4**	**5**
Reduce production flow time	0,7727	-0,2161	-0,1049	-0,2847	0,1341
Decrease new product introduction time	0,7309	-0,0108	-0,4951	-0,1685	-0,3307
Increase production rate	0,6874	-0,3038	0,2095	-0,3891	0,0179
Reduce break-even points	0,6569	-0,2721	-0,0763	0,0566	0,0235
Decrease unit cost	0,6489	-0,1981	0,1697	0,3403	0,2548
Increase delivery reliability	0,6419	0,4137	-0,0002	0,2194	-0,0104
Reduce production lead time	0,5929	0,3360	0,2852	-0,0687	-0,2257
Increase direct labor productivity	0,5804	-0,5543	0,4107	0,1728	-0,1545
Increase conformance quality	0,5122	-0,0493	0,3630	0,4840	0,0067
Reduce set-up / changeover times	0,4630	0,4002	0,3642	-0,4558	0,0051
Decrease breakdowns and not planned stops	0,1475	0,7318	0,4037	0,1408	-0,1714
Decrease new product development time	0,5187	0,1442	-0,6286	0,0527	-0,4543
Increase market share	0,3833	0,2151	-0,4477	0,5106	0,3347
Producing high value added products	0,4311	0,2846	-0,1969	-0,2982	0,7006

Appendix G. Unrotated component matrix of 16 manufacturing objectives

	Component					
	1	2	3	4	5	6
Reduce production flow time	0,7680	-0,0695	-0,2412	-0,0812	-0,2405	-0,2201
Decrease new product introduction time	0,7188	0,2831	-0,2595	0,3078	-0,3171	0,2397
Reduce break-even points	0,6730	0,0525	-0,2855	-0,1064	0,1143	0,0461
Increase production rate	0,6723	-0,2649	-0,1947	-0,3164	-0,3267	-0,1252
Decrease unit cost	0,6631	-0,1797	-0,0960	-0,1077	0,4781	-0,0692
Increase delivery reliability	0,6389	-0,1429	0,3427	0,3123	0,0482	-0,0168
Increase direct labor productivity	0,5596	-0,4986	-0,3330	-0,3312	0,1917	0,2234
Reduce production lead time	0,5385	-0,4613	0,3512	0,1858	-0,3372	0,0175
Increase end products stock turnover rate	0,4641	0,7005	0,0794	-0,4187	0,0427	0,1085
Increase input materials stock turnover rate	0,5217	0,6084	0,1224	-0,2529	0,3588	0,1446
Increase conformance quality	0,4728	-0,5217	0,0690	0,0914	0,3881	0,0658
Decrease breakdowns and not planned stops	0,1960	-0,0059	0,8450	-0,0159	0,1298	0,2769
Reduce set-up / changeover times	0,5056	-0,0738	0,5183	-0,2931	-0,3128	-0,0407
Increase market share	0,3725	0,0761	-0,0160	0,6373	0,3649	-0,3129
Decrease new product development time	0,5082	0,3613	-0,1718	0,5408	-0,1832	0,4025
Producing high value added products	0,4304	0,3744	0,1606	0,0108	-0,0436	-0,7124

Appendix H. Unrotated component matrix of 35 action plans

	Component									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Training of managers	0,8061	-0,0859	-0,2995	-0,1655	0,1393	-0,0624	0,0661	-0,0846	0,0072	0,1130
Zero defect	0,7868	0,1388	0,1342	-0,2662	0,0213	0,1532	-0,1936	-0,0555	0,0231	-0,0579
Preventive maintenance	0,7823	0,0313	-0,2103	0,0827	0,0673	0,2054	0,0582	0,2370	-0,0029	-0,0979
Green production technologies	0,7682	-0,0385	0,0462	-0,1102	-0,0095	0,0211	0,2404	0,2760	0,0172	0,0542
Improvement of QC lab facilities	0,7645	-0,1865	0,0578	-0,1113	-0,0914	0,2577	0,1707	-0,4090	-0,0300	0,1059
Energy saving	0,7559	-0,1121	-0,0438	0,2695	-0,0972	0,1939	0,1357	0,2704	-0,0856	0,0026
Quality certificates for products	0,7427	-0,0478	0,1875	-0,2238	-0,1764	-0,2815	-0,0969	-0,2438	-0,0540	0,0875
Quality certificates for environment protection	0,7257	-0,2540	0,2907	-0,2502	-0,1036	0,0203	0,0384	0,1506	-0,1355	-0,2100
Using internet in supply chain	0,6961	-0,0489	0,0587	-0,3136	-0,3319	-0,0238	0,0227	0,0810	-0,2659	-0,0848
Production automation	0,6940	0,1159	0,2418	-0,3759	-0,2533	-0,1318	-0,0992	-0,0115	-0,0698	0,1983
Reducing setup / changeover times	0,6884	0,0318	-0,0590	-0,1836	0,2087	-0,2498	0,3395	-0,2929	0,0457	-0,2095
Statistical process control	0,6675	-0,0865	-0,1391	0,3881	0,0394	0,2465	0,1972	-0,0382	0,0676	0,1188
Conformance to environmental standards	0,6535	-0,2861	0,0636	0,2611	0,1077	-0,0424	-0,0071	0,3445	-0,0218	-0,0489
Quality certificates for processes and management	0,6449	0,0678	0,1724	-0,1788	-0,2292	-0,1243	-0,1937	0,1238	0,2914	-0,1075
Quality circles / Quality improvement teams	0,5934	-0,0815	0,2989	0,2203	-0,1028	0,4025	-0,2647	-0,1045	-0,0366	0,0386
Activity based costing (ABC)	0,5880	-0,1113	0,2311	0,1910	0,5196	0,3157	-0,1923	-0,0412	-0,1283	0,1814
Aligning customer needs and product development	0,5821	0,3054	-0,3138	0,1501	0,2890	-0,2459	-0,2151	-0,1228	-0,0850	-0,2705
Warehouse management	0,5283	0,1930	-0,0897	0,2268	-0,4188	-0,3218	0,1199	-0,0052	0,2632	0,3533

Appendix H. Unrotated component matrix of 35 action plans (continued)

	Component									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Improving after sales service	0,4681	0,0885	-0,3848	0,4189	-0,3804	-0,1159	0,0601	0,0168	0,2745	0,0768
Improvement of supplier relationships	0,4119	0,1788	-0,3797	-0,3287	0,4084	0,0955	0,3308	-0,1584	-0,1364	0,1497
JIT production	0,1065	0,8138	-0,0272	0,0549	0,2939	-0,1634	-0,0216	-0,1430	0,0918	0,1879
Developing new processes for new products	0,2384	0,7859	0,1345	-0,2289	-0,0302	-0,0734	0,0163	0,1267	-0,0426	-0,1816
JIT procurement	-0,0575	0,7595	0,3766	0,0756	-0,1063	-0,2867	0,0905	-0,1372	0,0111	-0,0431
Developing new processes for existing products	-0,0680	0,7512	0,0663	0,2571	0,2087	-0,0504	0,1685	0,0243	0,1594	-0,2101
Integration of information systems of functions	0,0634	0,7321	0,0618	-0,0144	-0,4107	0,3149	0,2030	-0,2290	-0,0339	-0,1015
Linking manufacturing strategy to business strategy	-0,1624	0,7072	0,1635	0,1436	-0,3140	0,3818	-0,0994	0,0318	-0,2511	-0,0712
Total Quality Management program	0,0464	0,5634	0,0737	-0,1529	0,2465	-0,0014	-0,0030	0,2360	-0,2738	0,5294
Employee empowerment	0,1902	0,4839	-0,3772	-0,2482	0,1121	0,2825	-0,0147	0,1916	0,4033	0,0707
Restructuring	0,0884	0,4787	0,3269	0,4158	0,0581	-0,1694	0,3551	0,2736	-0,2307	-0,0221
Training of employees (Excluding managers)	0,5650	-0,0063	-0,6012	0,0387	-0,0372	-0,0974	0,0131	0,0683	-0,2297	-0,3178
Manufacturing resource planning	0,3146	-0,4639	0,5509	0,0397	0,0907	0,0884	0,3008	0,0252	0,3994	-0,0162
Value engineering / Redesign of products	0,5000	0,1020	0,1030	0,5794	0,0920	0,2540	-0,1541	-0,3554	-0,0047	-0,0797
Automation of production and inventory control systems	0,4353	0,1990	0,4369	-0,1100	0,4975	-0,1512	-0,2491	0,0935	0,2576	-0,1531
Cross-functional teams	-0,2197	0,4615	-0,2307	-0,3930	-0,0744	0,5567	-0,1311	0,1081	0,2527	-0,0633
Computer aided design (CAD)	0,5635	0,1875	-0,2449	0,2163	-0,1024	-0,2888	-0,5732	0,0484	-0,0190	0,1199

Appendix I. Unrotated component matrix of selected 27 action plans

	Component						
	1	2	3	4	5	6	7
Training of managers	0,7965	-0,2902	-0,2003	0,0934	-0,2076	0,0245	-0,0221
Zero defect	0,7857	-0,0415	-0,1242	-0,2984	0,2143	0,2078	-0,0503
Green production technologies	0,7405	-0,1699	-0,0722	-0,1605	0,0761	0,0159	0,2387
Preventive maintenance	0,7392	-0,1474	-0,0208	0,2444	0,1555	0,3565	0,1326
Quality certificates for products	0,7287	-0,1839	0,0987	-0,4099	0,0060	-0,1939	-0,1213
Reducing setup / changeover times	0,7167	-0,1175	-0,2334	-0,0966	-0,0676	-0,3631	0,1867
Energy saving	0,7150	-0,2340	0,2104	0,1184	0,2099	0,1254	0,3495
Production automation	0,7040	-0,0259	0,0366	-0,5891	-0,0106	0,0407	-0,0788
Aligning customer needs and product development	0,6700	0,1174	-0,1022	0,3782	-0,0720	-0,2072	-0,3170
Quality certificates for processes and management	0,6682	-0,0697	0,1995	-0,3853	-0,0683	0,0782	-0,0532
Training of employees (Excluding managers)	0,6318	-0,2074	-0,0098	0,3427	-0,3597	-0,0466	0,1058
Warehouse management	0,6072	0,0863	0,4598	-0,0770	-0,2743	-0,1620	0,0674
Employee empowerment	0,3408	0,3192	-0,3305	0,1456	-0,2943	0,2753	0,0983
JIT procurement	0,0714	0,8235	0,1520	-0,2432	0,0040	-0,2575	-0,0680
Linking manufacturing strategy to business strategy	-0,0730	0,7743	0,1967	0,0375	0,1169	0,4482	0,0501
Developing new processes for existing products	0,1090	0,7613	-0,0277	0,2913	0,0422	-0,2431	0,0880
Integration of information systems of functions	0,1931	0,7348	0,1602	-0,0665	-0,1049	0,2852	0,3280
JIT production	0,3214	0,7332	-0,2141	0,1033	0,0132	-0,1935	-0,2292
Developing new processes for new products	0,3530	0,7229	-0,1152	-0,1443	-0,1282	0,1568	-0,0648
Restructuring	0,2009	0,5379	0,1411	0,0187	0,3369	-0,4312	0,3085
Total Quality Management program	0,1458	0,5350	-0,3880	-0,0993	0,0807	0,1809	-0,2229
Improvement of supplier relationships	0,5041	0,0119	-0,6295	0,1475	-0,2423	-0,0971	0,1920
Improving after sales service	0,5016	-0,0161	0,5366	0,3754	-0,3051	0,1137	-0,0372
Activity based costing (ABC)	0,4710	-0,1929	-0,2636	0,1653	0,7158	0,1049	-0,1647
Value engineering / Redesign of products	0,5013	0,0383	0,2731	0,3225	0,5106	-0,1083	0,0664
Computer aided design (CAD)	0,5951	0,0165	0,2834	0,1821	-0,0290	0,0540	-0,6420
Improving after sales services	-0,0485	0,1026	0,2532		0,3954	0,1525	0,7079

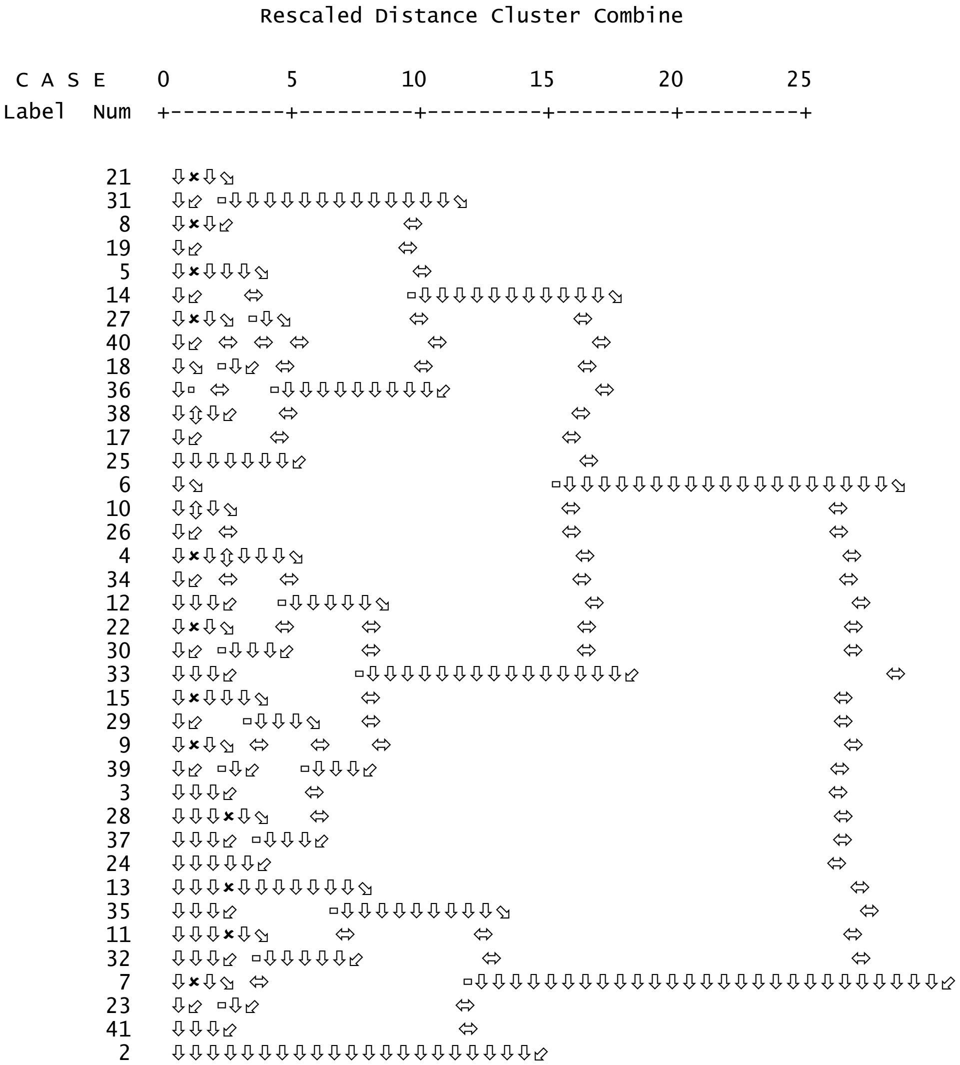
Appendix J. Unrotated component matrix of the most important 20 action plans

	Component					
	1	**2**	**3**	**4**	**5**	**6**
Zero defect	0,8102	-0,1067	-0,0890	-0,2436	-0,0515	0,2668
Training of managers	0,7568	-0,3660	0,1971	0,1726	-0,1346	-0,0154
Production automation	0,7564	-0,0791	-0,2662	-0,3607	-0,0250	0,1652
Quality certificates for products	0,7539	-0,2669	-0,2732	-0,2126	0,0387	-0,0889
Green production technologies	0,7327	-0,2551	-0,0058	-0,1654	-0,0322	0,0238
Reducing setup / changeover times	0,7252	-0,2185	0,1449	-0,1907	-0,1244	-0,4208
Quality certificates for processes and management	0,6756	-0,1162	-0,3921	-0,1540	-0,1109	0,0769
Aligning customer needs and product development	0,6684	0,0369	0,1092	0,4269	0,1967	-0,2140
Computer aided design (CAD)	0,5839	-0,0499	-0,2830	0,5404	0,2906	0,1803
Linking manufacturing strategy to business strategy	-0,0256	0,8283	-0,2039	0,0736	-0,0429	0,3124
JIT procurement	0,1696	0,8033	-0,1922	-0,1553	0,0976	-0,2833
Integration of information systems of functions	0,2345	0,7400	-0,1395	-0,0417	-0,4207	0,0574
Developing new processes for new products	0,4511	0,6917	-0,0121	-0,0267	-0,0996	0,0583
JIT production	0,4255	0,6622	0,2515	0,1683	0,1669	-0,1770
Total Quality Management program	0,2348	0,5410	0,3733	-0,0857	0,3118	0,3309
Restructuring	0,2044	0,5022	-0,0504	-0,2316	0,4216	-0,4183
Improvement of supplier relationships	0,5321	-0,0471	0,6710	0,0029	-0,2247	-0,1336
Improving after sales service	0,4060	-0,0537	-0,3667	0,6456	-0,1257	-0,1331
Activity based costing (ABC)	0,4500	-0,2574	0,2565	-0,0481	0,5504	0,3388
Employee empowerment	0,3778	0,2741	0,3819	0,1754	-0,4256	0,2200

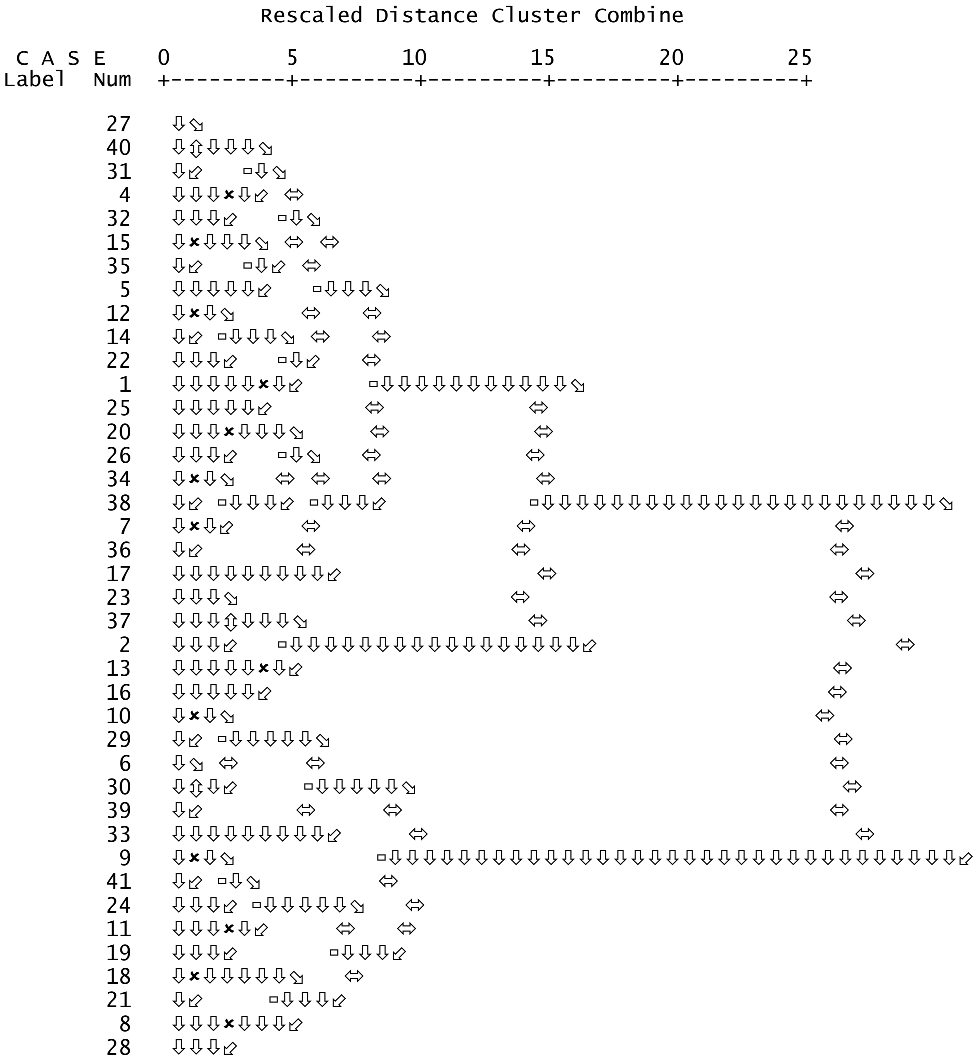
Appendix K. Unrotated component matrix of the most used 20 action plans

	Component					
	1	2	3	4	5	6
Training of managers	0,7345	-0,4045	0,3192	0,0696	0,0007	0,0210
Aligning customer needs and product development	0,7189	-0,0089	0,1785	-0,3000	-0,2961	0,3223
Preventive maintenance	0,7020	-0,2862	0,0674	-0,0497	0,2744	-0,1206
Energy saving	0,6751	-0,3770	-0,1923	0,0204	0,4993	0,0455
Warehouse management	0,6628	-0,0322	-0,3643	0,1877	-0,0419	-0,2599
Training of employees (Excluding managers)	0,6397	-0,3629	0,2357	-0,2589	-0,0050	0,0600
Computer aided design (CAD)	0,6374	-0,1198	-0,1648	-0,0763	-0,5746	0,0894
Quality certificates for products	0,6260	-0,2617	-0,1560	0,4614	-0,0691	0,2246
Quality certificates for processes and management	0,6090	-0,1812	-0,1830	0,4892	-0,0460	-0,0029
Improving after sales services	0,5961	-0,1952	-0,2933	-0,2260	-0,2386	-0,4126
Value engineering / Redesign of products	0,5077	-0,0621	-0,3903	-0,4060	0,2050	0,1506
JIT procurement	0,1968	0,8112	-0,2677	0,1737	-0,0881	0,1005
Developing new processes for existing products	0,2615	0,7425	-0,0352	-0,3844	-0,0009	0,0044
JIT production	0,4506	0,7017	0,1446	-0,0549	-0,1539	0,1404
Developing new processes for new products	0,4472	0,6494	0,1288	0,1950	-0,0701	-0,0708
Integration of information systems of functions	0,3102	0,6227	-0,1170	0,0295	0,2044	-0,4467
Restructuring	0,2690	0,5321	-0,3495	-0,0744	0,3968	0,3696
Total Quality Management program	0,2094	0,5293	0,3459	0,2966	0,0152	0,1407
Improvement of supplier relationships	0,4875	-0,0123	0,6642	0,0149	0,2331	0,1034
Employee empowerment	0,3972	0,2749	0,4298	-0,0628	0,0520	-0,4507

Appendix L. Dendrogram for clustering according to 12 competitive priorities



Appendix M. Dendrogram for clustering according to 14 manufacturing objectives



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