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The Industrial Application of Patent Analysis: An Empirical Study

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Abstract

This research investigates the value of patent analysis in an industrial context. An empirical approach is taken to test the benefits and limitations of a series of patent analysis techniques. The technology profiles of a group of competitor companies within the oil/petrochemicals area are mapped to evaluate the analysis techniques.

Patent quantity analysis benefits from speed of execution but provides no indication of patent quality. The International Patent Classification (IPC) hierarchy can map a company's technological diversity but the correlation of IPC categories with industry or product areas may present difficulties in a business-focused analysis.

An experiment within the polymer chemistry area suggests there is a positive association between a patent's citation counts and its commercial significance, as rated by expert grading. This supports the use of patent citation data to compare the quality of companies' patent portfolios but the time lag to build citation counts may limit its usefulness in practice.

Maps of inter-company patent references may indicate technological leadership but the value of other bibliographic-based techniques appears more marginal. A trend of inter-company differences in the volume of the 'References Cited' list is observed. If confirmed, this could impact the value of bibliographic-based patent analysis techniques.

Patent analysis can assist in a merger evaluation, particularly at the due diligence phase, but it is often of secondary importance to financial and product market information.

Several factors that may distort patent statistics are identified. These include inadequate company name consolidation, errors in patent classification and differences in national patent legislation. The study concludes that patent analysis has a valid place in the corporate environment, provided the output is interpreted judiciously.

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CONTENTS

Chapter Three Methodology

Chapter Four Patent Quantity & Technology Area Analysis

Chapter Five Patent Citation Analysis

TABLES & FIGURES

Chapter Seven Technology Fit of Merger Candidates

Appendix A1 Patent Analysis Pilot Study

Appendix A2 Technology Area Analysis – Additional Data

Appendix A3 Patent Citation Analysis – Additional Data

CHAPTER ONE
INTRODUCTION

> "We have a choice of using patent data cautiously and learning what we can from them, or not using them and learning nothing about what they alone can teach us."

Jacob Schmookler, 1966. *Invention and Economic Growth* Cambridge, Mass. p.56.

1.1 Background to the Study

Ever since its first codification in the 15th Century, the intention of the patent system has been to act as an incentive for technical progress and improve the efficiency of the capitalist economic system (Granstrand, 2000). The patent owner is granted a temporary monopoly right and, in return, a detailed technical disclosure of the invention enters the public domain. Over time, this set of patent documents builds to form an unique record of technological developments.

The analysis of patent data may therefore provide perspective on the rate and direction of technical progress and patent statistics have been used as both technological and economic indicators. One advantage of patent-based methods is that the patent examination process introduces an element of quality control into the standard of the data. A further benefit is that patent data can be aggregated at different levels, depending on the purpose of the analysis. On a macro-economic level, patent analysis has been used to compare the technological output of countries (Jain and Triandis, 1997, p.280). On a more detailed level, patent analysis has been applied to monitor competitor activity (Castells *et al*, 2000) and has even been recommended as a predictor of stock market success (Barker, 2002).

The practitioners of patent analysis acknowledge that the technique has its limitations and caution must be exercised in both the preparation and interpretation of patent statistics. Distortions may be introduced through differences in national patent legislation or differences in companies' attitudes towards patenting (Granstrand, 2000). A further concern is that the economic importance of patents is extremely skewed, with a small group of highly significant patents generating the bulk of the value (Basberg, 1987).

Several methods have been developed to improve the quality of the patent statistics by focusing on the economically important inventions. International patent application data and patent maintenance statistics have both been used as patent 'quality' filters, based on the rationale that inventors will continue to invest further resources in only their most significant developments (Basberg, 1987). A third approach to identifying high quality patents is based on measuring the extent of citation (referencing) between patents. The hypothesis underlying this technique is that patents which relate to significant technical developments will be more highly cited than patents disclosing less significant inventions (Narin *et al*, 1984). More recently, the analysis of other patent bibliographic information (e.g. references to scientific papers) has been proposed as a further route to measure patent quality (Narin, 2000).

The majority of publications concerning patent analysis have focused on its use as an economic indicator. However, a few researchers have described the potential applications of patent analysis in an industrial context, such as identifying new technology trends or comparing the output of competitor companies (Breitzman and Mogee, 2002). The use of patent statistics to analyse mergers and acquisitions has also received attention recently (Breitzman *et al*, 2002), reflecting a more widespread interest in strategic alliances as a means of technology acquisition (Trott, 1998).

Advocates of patent analysis claim it is a valuable tool to understand the competitive environment and to inform business strategy development (Breitzman and Mogee, 2002). Indeed, several consultancies have been established to provide patent analysis services (see, for example, http://www.mogee.com, http://www.chiresearch.com and http://www.metricsgroup.com). However, only limited data are available in the public domain describing the process and outcome of such analyses.

1.2 Aims of the Study

The research topic for the current study is to explore the value of patent analysis in an industrial context. The study tests a range of patent analysis techniques and examines the value of their output in relation to the resources required to conduct the analysis. The study focuses on the application of patent analysis to compare the technology profiles of a group of competitor companies. An empirical approach is taken to investigate the feasibility of conducting such a study without access to proprietary analysis tools. A key objective of the research is to identify the practical considerations which impact the usefulness of patent analysis within the corporate environment.

The specific research questions this study aims to address are as follows:

- What are the benefits and limitations of a simple patent quantity analysis?
- What are the benefits and limitations of using International Patent Classification (IPC) data to measure technological diversity?
- Is there an association between patent citation counts and the commercial significance of a patent?
- What are the benefits and limitations of patent bibliographic analysis?
- To what extent do patent statistics add value in a merger analysis?

1.3 Structure of the Dissertation

Chapter Two of the dissertation presents a literature review which explores the history and applications of patent analysis. The issues associated with the collection and interpretation of patent statistics are identified and discussed.

The methodology employed in the current study is described in Chapter Three. The data sources, data collection and data analysis methods are explained in detail. The terms used within the study are defined and the limitations of the research are reviewed.

Chapter Four presents the results of the first stage of the patent analysis. The findings of the patent quantity and technology area analysis are summarised and discussed. The practical challenges and limitations identified during this phase of the study are also reviewed.

The results of the patent citation analysis are summarised in Chapter Five. A small experiment to test the validity of citation counts as an indicator of commercial significance is described and the implications of the test findings are discussed. The Chapter also contains a summary of the methodological issues identified during this phase of the analysis.

Chapter Six reviews the patent bibliographic analysis conducted as part of the current study. Three indicators, based on patent reference information, are investigated. The benefits and limitations of these bibliographic techniques are discussed in light of the findings of the current study.

The application of patent analysis to evaluate a merger is described in Chapter Seven. The pre-merger patent portfolios of two companies are compared to explore the degree of ‘technology fit’ between the merger candidates. The business press commentary regarding the merger is summarised and the implications regarding the usefulness of patent information for merger analysis are discussed.

Chapter Eight presents a summary of the key findings of the current research. The practicalities of conducting a company-focused patent analysis are reviewed, based on the experience of this empirical study. The dissertation concludes with an assessment of the value of patent analysis within the corporate environment.

CHAPTER TWO
LITERATURE REVIEW

2.1 Chapter Two Overview

This Chapter surveys the literature regarding the applications of patent analysis. Firstly, the rationale behind the use of patent documents as an information source is reviewed. Patent analysis is then placed in context as one of several approaches to measure 'innovation'. The issues associated with the use of patent statistics are identified and approaches to filter patent 'quality' are discussed. The applications of patent analysis in the corporate environment are reviewed, focusing on the areas of company valuation, competitive intelligence and technology acquisition. The development and validity of patent citation analysis as a technique to identify significant patents is explored. The Chapter concludes with a summary of the key themes identified in the literature review and explains how the current study attempts to build on these themes.

2.2 Patents as an Information Source

The grant of a patent involves a 'bargain' between the inventor and the State. The inventor is granted a fixed-term monopoly over the exploitation of his invention and in return a detailed disclosure of the invention enters the public domain in the form of the patent document (Phillips and Firth, 2001, p.35). Over time, the set of patent documents builds an unique record of technological output and many researchers have focused their efforts on analysis of these documents to provide perspective on technological productivity.

Granstrand (2000, Chapter 9) provides an excellent overview of the use of patents as a source of technical information. A major advantage of patents as an information source is their broad coverage in terms of geography, time frame and technology areas. However, patent data must be interpreted cautiously due to several factors such as differences in national patent systems and the differences in attitude towards patenting that exist between different companies (Granstrand, 2000, Section 9.2.3).

Granstrand also reviews the various uses that have been suggested for patent data, ranging from international economic analysis to valuation of a company's technology assets.

Other authors have focused on specific applications of patent analysis is their reviews of the topic. Basberg (1987) reviews the use of patent statistics in economic analysis and Breitzman and Mogee (2002) identify potential applications of patent analysis within the corporate environment. Okubo (1997) refers to patent analysis techniques within a broader review of bibliographic methods used to evaluate science and technology.

2.3 The Measurement of 'Innovation'

Acs *et al* (2002) observe that, historically, economic growth and development have been largely underpinned by advances in knowledge and innovation. How to measure 'innovation' is therefore of interest to a variety of practitioners, ranging from economists and historians to business managers. Economists are interested in the role of innovation in economic growth, international trade and regional development whereas historians are concerned with the evolution of technology over time. Business managers wish to evaluate aspects of their firm's performance, ranging from the efficiency of their research and development (R&D) organisation to their overall position within the competitive environment.

Three main approaches have been used to evaluate different aspects of the innovation process. The first approach measures inputs to the process such as R&D expenditure; the second measures intermediate outputs such as patented inventions and the third approach involves a direct measure of innovative output (Acs *et al*, 2002). Geisler (2002) expands on this theme, listing examples of financial and commercial metrics to evaluate innovation. In his review, Geisler also identifies the key criteria for selection of appropriate metrics. He notes that the metrics selected should be able to measure what the evaluators wish to be measured; the data used by these metrics should be available, affordable and accessible or quality may suffer; thirdly, it should be possible to manipulate the data, to allow for interpretation and comparison with other metrics.

Measures of innovation inputs, such as R&D expenditure, can be relatively easy to obtain and may indicate the level of commitment to innovation but they provide no information on how efficiently these resources are used. Chakrabarti (1989) reviews approaches to the direct measurement of innovative output. This involves two stages, the identification of innovations (via literature review, expert opinion or surveys) and the subsequent rating of these innovations (by expert panels or surveys of industrial firms) to evaluate their quality and impact. The challenges here include low response rates to surveys and difficulties in establishing a suitable panel of experts.

2.4 The Use of Patent Statistics to Measure Innovation

Given the difficulties with direct measures of innovation, much attention has been given to indirect measures based on bibliographic information, in particular patent statistics. Basberg (1987) reviews the literature using patent statistics as a technology indicator, noting that the studies fall into three main categories. The most numerous category deals with the relationship between technological change (as measured by patent statistics) and economic development (see, for example, Schmookler, 1966; Griliches, 1990). The second application of patent analysis relates to the diffusion of technology from one country to another (see, for example, Eaton and Kortum, 1999). The third group of studies analyse the innovation process itself and the relationship between R&D, patenting and innovative output.

There is considerable debate in the literature regarding the suitability of patent statistics as a measure of innovation. According to Pakes and Griliches (1980, p. 378), "patents are a flawed measure [of innovative output] particularly since not all new innovations are patented and since patents differ greatly in their economic impact." Chakrabarti (1987) and Buderi (1999) express a similar sentiment, claiming that measuring patenting trends is not a sufficient measure of innovation. Other researchers have attempted to investigate the relationship between R&D, patenting and innovation. Pavitt (1982) concludes that R&D activity and patenting activity are complementary but may not be perfect reflections of each other. However, both data sets taken together provide a more complete picture of the innovation process; for example, in the motor vehicle industry, R&D spend was high relative to patenting rates, possibly due to a greater focus on technical testing versus other industries. More recently, Acs *et al* (2002) compared patent counts with a database containing direct innovation counts in an assessment of regional knowledge flow and concluded that "the measure of patented inventions provides a fairly good, although not perfect, representation of innovative activity."

Furman *et al* (2002) have produced a detailed empirical analysis of the factors that influence country-level production of international patents. They conclude that whilst factors such as R&D expenditure account for a great deal of the variation in patenting levels between countries, more fundamental national policy choices are also important factors. These policy choices reflect national support for innovation, such as the strength of intellectual property protection and openness to international trade.

Basberg (1987) summarises the problems associated with the use of patent statistics as technology indicators and lists some approaches to address these shortcomings. A key concern is that simple patent counts do not reflect the varying value or quality of the patents. Granstrand (2000, p.58) notes that patents may be of technical value, commercial value or economic value but that the criteria for each of these are significantly different. Secondly, the time intervals separating R&D expenditure, patenting and commercialisation may have an impact on the analysis. A further concern is that attitudes towards patenting may vary considerably between firms and between industries, raising concerns about the validity of such comparisons. Comparisons between countries also raise concerns regarding differences in patent legislation and how this affects patent data.

There are many reasons why firms choose not to patent innovations (Basberg, 1987). The firm may not be able to afford patenting; patenting may provide too limited a barrier to imitation; the expected economic life of the innovation may be too short to justify patenting or the innovation itself may not be patentable due to specific exclusions in patent law (see, for example, European Patent Convention 1973 Article 52 which excludes "programs for computers").

Basberg (1987) also notes other challenges in the analysis of patent data. One problem is that patent classification and industry classification use different systems, requiring some form of data transformation to investigate relationships between patenting and economic activity. The underlying issue is that patent classification is invention based rather than application based and so transformation into industry-related groupings is liable to introduce further errors into the analysis. A further consideration is whether patent application data or information on granted patents should be used. Application data reflect the inventors' interest in technologies at an early stage of the innovation process and are not distorted by delays in the patent examination process. However, studies on granted patents contain the additional quality filter of approval by the relevant patent authorities.

2.5 Patent 'Quality' Assessment

Basberg (1987) identifies several approaches to introduce a 'quality' filter into patent data in an attempt to improve the validity of patent statistics as a measure of innovation. A first approach is a simple rating of a patent's importance but this involves a subjective estimate of patent quality and may be subject to bias. A more objective approach is to use the effective life of the patent to estimate quality. This assumes that only the most profitable inventions can justify the payment of (ever-increasing) patent maintenance fees. Phillips and Firth (2001, p.76-79) list this and other potential explanations for the extent of non-renewal in the UK. Renewal statistics in the US may be less sensitive than other geographies because US patent maintenance fees are due only three times during the patent lifetime (http://www.uspto.gov), whereas annual maintenance fees are more typical in other countries (see, for example, http://www.patent.gov.uk).

Measures based on patenting abroad are another approach to filter patent data for quality. This approach assumes that only inventions with significant expectations for success will be patented abroad because of the increased costs involved in the process of international patent filing. Recently, Grupp and Schmoch (1999) have highlighted the particular difficulties with patent statistics in the age of multi-national firms. One issue is how to designate the country of origin of a patent for counting purposes; options include the country of first filing, the country of residence of the inventors or the location of the company headquarters. The increasing use of the Patent Cooperation Treaty (PCT) system to file patents internationally also introduces challenges for patent analysis. Specifically, under the PCT system, companies can delay the payment of national patent filing fees until approximately 30 months after the priority date (PCT 1970 Article 22). Companies are therefore able to defer a decision on the importance of the technology until this point, making it difficult to introduce a 'quality' filter based on perceived importance at an earlier stage in the patent's lifetime. The Organisation for Economic Cooperation and Development (OECD) has recognised these difficulties and is developing a single patent database to allow consistent assessment of international science and technology performance (OECD, 2002).

One further approach to determine patent quality uses citation analysis to identify significant patents. Patent applications typically contain references to earlier, closely related patent documents. The citation analysis method assumes that the more often a patent is referred to by subsequent patents, the more important it is likely to be. The applications of this method build largely on the work of Francis Narin and co-workers at CHI Research Inc. (http://www.chiresearch.com) and are discussed further in Section 2.9.

One issue with citation analysis is that differences in national patent laws necessitate different definitions of a 'citation'. The majority of patent citation studies have focused on US patents, where there is a specific legal requirement for the applicant to inform the Patent Examiner of all relevant prior art (37 Code of Federal Regulations Section 1.56). The final decision on what is included in the 'References Cited' section of the US patent rests with the Patent Examiner, who may add to or subtract from the list supplied by the applicant. However, the situation is significantly different in other geographies. For example, in Europe, there is no corresponding obligation to produce a 'References Cited' list. Instead, 'citations' may arise from the European Patent Examiner's search report as part of the examination procedure or the applicant may refer to earlier patents within the text of the patent application.

2.6 The Use of Patent Analysis for Company Valuation

The preceding Sections of this literature review have focused on studies of macro-economic trends using patent statistics. However, the same principles can be applied to study the performance of individual companies or to compare the performance of groups of companies. Studies at the company level are also subject to the difficulties with patent analysis discussed in Section 2.4, such as how to evaluate patent quality or how national differences in patent legislation affect patent statistics.

The growing disparity between the stock market value of companies and the book value of their assets has led to an increased focus on patents and other intangibles by the business community (The Economist, 1999). Lev (2001) concludes that, on average, for the largest 500 companies in the US, for "every $6 of market value, only $1 appears on the balance sheet, while the remaining $5 represents intangible assets."

There is a growing realisation that financial measures alone are insufficient to describe the 'value' of a company and Chatzkel (2001) reports a study that identified nine non-financial measures which help to explain the stock-market value of companies. 'Innnovation' was identified as one of the key factors for many companies, with a combination of R&D expenditure, number of patents and patent importance (based on citation counts) being used in the model to approximate 'innovation'.

Building on this approach, patent citation analysis has recently shown promise as a technique to value companies (Breitzman and Mogee, 2002) or even to predict the stock market success of technology companies (Barker, 2002). Indeed, the developers of this approach to selecting a stock market portfolio have patented their technique (US6175824: Method and apparatus for choosing stock portfolio, based on patent indicators. CHI Research Inc.).

2.7 The Use of Patent Analysis for Company Benchmarking and Competitive Intelligence

The business use of patent citation analysis to assess corporate technical performance was proposed by Narin *et al* nearly twenty years ago (Narin *et al*, 1984). The applications suggested include competitor analysis and as a measure of R&D productivity. Robb (1991) confirms that patent analysis techniques, though imperfect, are one of the best tools used to measure research and development productivity within General Electric.

Narin *et al* (1984) note the advantages of patent analysis include the ability to investigate at different levels of detail, for example, to study overall company performance or to focus on a specific technology area. A further benefit is that the method is unobtrusive to conduct. It is acknowledged that normalisation of data is required to make comparisons between different technology fields or across different time frames. Even if data normalisation is possible, differences between industries or between companies' patenting policies may affect the validity of such cross-comparisons. Breitzman and Mogee (2002) advise that a thorough benchmarking study involves a measurement of quantity of patents and also quality measures such as those based on numbers of foreign patents or number of citations received. In the US, company benchmarking using patent analysis occurs on an annual basis across a range of industrial sectors (Technology Review, 2002).

Breitzman and Mogee (2002) note that patents are an importance source of competitive intelligence. Patent analysis can track the technological direction of competitor organisations and provide an early warning of new entrants into a field. Castells *et al* (2000) observe that patent analysis is particularly powerful when combined with market research information. It is then possible to combine R&D trends with market trends to identify growing or stagnating technology areas and hence inform business strategy decisions.

2.8 The Use of Patent Analysis for Technology Acquisition

The growth of globalisation and decreases in technology lifecycles have resulted in changes within research and development management, with an increased focus on external technology acquisition (Trott, 1998, p.200). This external technology acquisition may take the form of strategic alliances, such as licensing agreements or joint ventures (Biemans, 2000) or more permanent arrangements such as mergers and acquisitions. Rivette and Kline (2000, p.148) highlight the important role patents can play in the merger and acquisition process. The pharmaceutical industry, in particular, has seen a recent wave of mergers as companies seek to maintain a strong product pipeline (Managing Intellectual Property, 1999). Several recent publications have demonstrated the application of patent analysis to assess merger and acquisition candidates (see, for example, Breitzman and Mogee, 2002). Typically, patent classification and key-word searches can be used to identify potential partners, coupled with patent quality analysis to determine the most suitable partner.

Breitzman and Thomas (2002) describe how patent citation analysis can identify potential acquisition targets and screen their suitability. They report that patent citation analysis may also be valuable during the due diligence process, for example, to confirm the retention of key scientists following the acquisition. In an empirical study using patent analysis, Ernst and Vitt (2000) found that key inventor retention following corporate acquisition is a significant problem and that the performance of retained key inventors has a tendency to decrease following acquisition.

A further application of patent citation analysis is to assess the technological compatibility of merger candidates. Breitzman *et al* (2002) discuss this compatibility assessment in more detail, using the Glaxo-Wellcome and SmithKline Beecham merger as a case study. The paper emphasises that the patent portfolios of merger candidates and their competitors should be analysed at several different levels of detail to obtain an overall picture of the competitive environment.

2.9 The Development and Validity of Patent Citation Analysis

As discussed in Section 2.5 above, patent citation analysis was developed as one route to introduce a 'quality' filter into patent statistics (Basberg, 1987). Patent citation measures were developed from the citation analysis techniques used to assess scientific journal articles (Okubo, 1997). Narin (2000) traces the history of citation analysis from the development of the *Science Citation Index* in the 1960s to the advent of patent citation analysis techniques in the late 1970s when patent citation data were first computerised. McAllister *et al* (1983) observe that whilst scientific publication analysis is appropriate for basic research institutes, patent statistics are a more relevant measure for applied research organisations.

Narin *et al* (1987) compare the results of patent analysis with other indicators of corporate performance for a group of 17 US pharmaceutical companies. They conclude that patent counts show the greatest correlation with factors occurring early in the innovation process (R&D expenditure, scientific publication) whereas patent citation counts are more strongly linked with outputs of the research process, such as the company's financial performance. The researchers note, however, that these findings may be unique to the pharmaceutical industry due to its particular reliance on patent protection.

Narin (2000) reviews studies which have attempted to validate the use of citation analysis to generate science and technology indicators. In general, these studies support the hypothesis that 'significant' patents tend to be more highly cited. As noted by Granstrand (2000, p.164), patent 'significance' can be tested on several different levels (technological, commercial, economic) and these validation studies have used a variety of different patent 'significance' measures to test the citation technique.

An early study (Carpenter *et al*, 1981) found that patents related to 'significant new technical products' (recipients of the US IR-100 award) received significantly more citations than a control group of patents. A later study (Albert *et al*, 1991) compared patent citation counts with expert rating of the technological importance of those patents. In that study, the group of very highly cited patents were rated significantly more important than patents receiving low citation counts, supporting the use of patent citation analysis to assess technological importance. A more recent study (Harhoff *et al*, 1999) explored the relationship between citation counts and the economic value of patents. This study found that patents renewed to full term (US, Germany) were significantly more highly cited than patents allowed to lapse before their full term. Additionally, a survey of the full-term patent holders indicated a trend for increasing economic value with increasing citation counts.

Narin (2000) and Breitzman *et al* (2002) propose that additional patent quality information can be extracted from the 'References Cited' section of US patent documents. One aspect of their technique (developed at CHI Research) measures the degree of linkage with fundamental scientific research by counting the number of references made to the scientific literature. A second indicator (technology cycle time) calculates the median age of the US patent references listed on the patent's front page. The intention here is to represent how quickly the current invention has built upon recent developments in the field. Narin (2000) reports differences in these indicators between different industrial sectors and Breitzman *et al* (2002) observe differences within a group of pharmaceutical companies. However, the validity of these indicators as a measure of technology quality has not been examined to the same extent as that of patent citation analysis.

2.10 Chapter Two Conclusions

This literature survey has confirmed that patent analysis has a long history in the measurement of technological innovation. The majority of studies have focused on using patent statistics to investigate and explain economic growth and development. However, several authors have recognised that patent analysis may be a valuable tool to evaluate the technological performance of companies, though little information on the outcome of such studies is available in the public domain.

Several caveats to the use of patent statistics were identified during the course of the literature review, emphasising that caution should be exercised when interpreting data. Attitudes towards patent protection can vary considerably between industries and even between companies within the same industry. These differences are further exacerbated when making international comparisons due to differences in national patent legislation.

Attempts to improve the quality of patent statistics have focused on techniques to identify the most significant patents. This is because the value of patents is highly skewed, with a high proportion of value lying within a small number of breakthrough inventions. Expert grading, patent renewal statistics and decisions on international patent filings have all been used as patent quality filters. Patent citation studies have also indicated that there is a positive relationship between high citation counts and the significance of a patent.

The current study aims to explore the practicalities of conducting a small scale patent analysis in an industrial context. Elements of the patent portfolios of competitor companies are compared, including the technology fit of two merger candidates. Patent citation analysis is investigated as an indicator of patent quality, together with more recently developed bibliographic techniques (science linkage and technology cycle time). A small experiment to test the validity of patent citation counts as an indicator of a patent's commercial significance is also included.

CHAPTER THREE
METHODOLOGY

3.1 Chapter Three Overview

This Chapter summarises the methodological approach to the current study. A positivistic paradigm was employed and the rationale behind this choice is discussed. The terms used in the study are defined and the limitations and delimitations of the research are reviewed. The sample selection, data collection and data analysis methods are described in detail.

3.2 Research Topic and Research Paradigm

The aim of the current study is to explore the practicalities of conducting a small scale patent analysis to compare the technology profiles of a group of competitor companies. The particular focus of the study is to assess the benefits and limitations of a range of patent analysis techniques. A further aim is to investigate whether patent analysis can provide additional insights into the technology basis of company merger decisions, as reported in recent research papers (see, for example, Breitzman *et al*, 2002).

The research was approached from a positivistic viewpoint (Hussey & Hussey, 1997, p.52) and based largely on empirical data collection from patent databases. The research topic allowed objective data collection, with minimal researcher influence or bias. Consistent with a positivistic approach, the study design was largely static in that the principal data sets and the methods of analysis were defined before the study began. Modifications were made during the study only if the data sets proved unmanageable or if new avenues were identified during the course of the research (Robson, 2002, p.96).

3.3 Definition of Terms

In the current study, patent analysis refers to measures of both the quantity and quality of granted patents. The study focuses on the analysis of patent bibliographic data and does not attempt to analyse the content of the patent text and claims. Additionally, the study looks only at individual patents and does not attempt to link them to larger patent families or international patent applications. The study does not investigate whether the patents are still active or have lapsed. Patent maintenance decisions can provide additional insights into the perceived value of patents (Basberg, 1987) but is beyond the scope of the current study.

In the current study, the 'quantity' aspect of patent analysis refers to measuring the number of granted patents. These may be grouped by company, time period or technology area. In this study, patents are subdivided into technology areas by means of the international patent classification system (IPC). The IPC is a hierarchical classification system and divides all technological fields into eight sections designated by the capital letters A to H. These sections are subdivided into classes (120 in total) symbolised by the IPC section symbol followed by a two-digit number. Each class contains further subclasses (628 in total) designated by an additional capital letter following the class symbol. The subclasses are further broken down into groups and subgroups to define more specific technology areas. In the current study, the subclass level was the most detailed level used to classify patents. A detailed description of the IPC system and definitions of the subdivisions is available from the World Intellectual Property Organisation (WIPO) website (http://www.wipo.org).

'Quality' indicators attempt to measure the real-world value of an individual patent or group of patents. The quality measures investigated in the current study are based on the referencing information contained within patent documents. Specifically, the study focuses on the patent analysis techniques reported by Breitzman *et al* (2002). These measures fall into four broad areas - patent impact, citation linkage, speed of innovation and links to scientific research.

Patent impact measures are based on citation counts i.e. the number of future patents which reference back to the patent under consideration. The hypothesis underlying this indicator is that patents relating to significant technical developments will be more highly cited than patents disclosing less significant inventions. In the current study, the principal quantity measured is ‘cites per patent’ (the number of citations received by that patent from subsequent patents). Patent citation analysis is investigated in detail in Chapter Five.

Citation linkage measures are based on citation counts between competitor companies. The hypothesis underlying this indicator is that companies that are technological leaders will be highly cited by their peers. In the current study, the principal quantity measured is ‘citation linkage from Company A to Company B’. This is the number of citations made to Company B’s patents within Company A’s patents granted during a particular year.

Speed of innovation measures are based on the age of the patents cited by the patent under consideration. The hypothesis underlying this indicator is that patents which cite relatively recent patents are more likely to be at the ‘cutting edge’ of their technology area than patents which cite older patents. In the current study, the principal quantity measured is ‘technology cycle time’ (the median age in years of the US patent references cited on the front page of that patent).

Links to scientific research measures are based on the number of references made to the scientific literature by the patent under consideration. The hypothesis underlying this indicator is that patents which cite large numbers of scientific papers are more likely to be building on fundamental scientific research than patents which cite few scientific papers. In the current study, the principal quantity measured is ‘science linkage’ (the mean number of science papers referenced on the front page of that patent).

The specific measures of patent impact, citation linkage, speed of innovation and links to scientific research in the current study differ slightly from those used by Breitzman *et al* (2002). This is because the Breitzman study normalises measures against data for the entire set of US patents, which is not feasible in the current study. In the current investigation, comparisons are only possible amongst the group of companies studied.

3.4 Data Collection – Data Sources

One aspect of the current study design was that data would be collected from free-to-use patent databases, rather than the commercial databases used in previous studies. The aim here was to explore whether useful results could be generated without access to proprietary analysis tools (see Bretizman and Mogee, 2002 for a list of some commercial patent analysis resources).

A pilot study was conducted to assess the feasibility of this approach and to identify the most appropriate data source for the main study (see Appendix A1). Three free-to-use patent databases accessible via the internet were investigated: the Delphion database (available from http://www.delphion.com), the *esp@cenet* network provided by the European Patent Office (available from http://ep.espacenet.com) and the US Patent and Trademark Office (USPTO) database (available from http://www.uspto.gov).

The Delphion database had limited search facilities available on a free basis. Free searching was limited to US patents and only patent number or keyword search terms could be constructed. However, the Delphion output was clearly formatted and included tables summarising the patent numbers, grant dates and assignees of patents referenced by that patent.

Of the three databases evaluated, the *esp@cenet* network provided access to the broadest range of patent information. The *esp@cenet* website allowed searching of PCT, European, and Japanese patent applications, together with information from approximately 50 other national patent offices. Searches could be conducted based on several search terms such as patent number, keywords or technology area (IPC symbols); however, it was not possible to specify a time range greater than one year for the search. A further drawback of the *esp@cenet* website was that country-specific or region-specific searches were only possible on patent applications up to 24 months old. Older documents could only be searched on a 'worldwide' basis, requiring additional manual sorting into countries or regions.

The USPTO website provided access only to US patents but provided the greatest flexibility of search terms. Complex Boolean search terms could be constructed to define time range, technology area, inventor, assignee or other search variables. Additionally, truncation of search terms was possible, for example, to retrieve all variants of a company name.

Following the pilot study, the USPTO database was selected as the principal data source for the main study. This is because the database was easy to use and allowed focused searching to generate the types of data sets required for the current investigation. This database choice limited the study to an evaluation of US patents but the literature search indicated that US patent data has been the primary source used in previous studies on patent bibliographic information. One reason for this choice has been the specific legal requirement in the US to list relevant prior patents on the front page of the patent document (Harhoff *et al*, 1999). A second reason has been the global importance of the US market, suggesting that US patent data may be representative of patenting activities in other geographies (Basberg, 1987).

3.5 Selection of Companies Studied

Previous industry-focused studies using patent statistics have concentrated on the pharmaceutical industry, largely due to that industry's heavy reliance on patent protection (see, for example, Narin *et al*, 1987). The current study aims to explore a different industrial sector which has experienced significant merger and acquisition activity in the past 5-10 years. The oil industry was selected because of its importance in the global economy and because the merger of the British Petroleum Company (BP) and the Amoco Corporation (Amoco) in 1998 resulted in the formation of Britain's largest company. The global dominance of a small group of oil companies allowed a manageable data set to be constructed.

In addition to BP and Amoco, a group of oil companies were selected to represent some of BP and Amoco's key competitors in the period immediately prior to their merger. The Exxon Corporation (Exxon) and the Royal Dutch/Shell Group (Shell) were selected because of their position as the two largest oil companies at that time (Hoover's, 1998a, 1998b). The Mobil Corporation (Mobil) was included because of its similar market value to BP and Amoco (Hoover's, 1998a, 1998b) and because it had been considered a potential merger candidate with BP in the financial press (Corzine, 1998).

During the early stages of the analysis, it became apparent that 'chemistry' patents formed a substantial part of the oil companies' patent portfolios. Consequently, three chemical companies with leading positions in the petrochemicals area were included in the analysis to compare and contrast with the oil companies. These chemical companies were the Union Carbide Corporation (Union Carbide), the Dow Chemical Company (Dow Chemical) and BASF AG (BASF).

Literature searches of the chemical industry press identified that inter-company strategic alliances have been a common feature within the petrochemicals area (see, for example, Murphy *et al*, 2000) and so two joint ventures (Montell and Targor) that were active during the period of interest were added to the analysis set later in the study. The reason for their inclusion was to explore whether the patenting behaviour of joint ventures differs from that of the parent companies. The Montell joint venture was formed between Shell and Montedison to exploit polypropylene technology and Targor was another polypropylene joint venture formed between BASF and Hoechst (Robinson, 2000).

Therefore, in total, the patent portfolios of 10 companies were studied in the current research: BP, Amoco, BASF, Dow Chemical, Union Carbide, Mobil, Exxon, Shell, Montell and Targor.

3.6 Database Search Terms

Table 3.1 overleaf lists the principal parameters used to define the search terms in the current study. For each required data set, the appropriate search string was constructed and the search conducted on the USPTO database. The searches were conducted over the period October to November 2002. Data for the citation analysis were collected over a two week period at the end of October 2002 to minimise variations in citation counts due to differences in the time of data collection.

Table 3.1 Search Parameters Used in USPTO Database Searches

	Search Parameters	Rationale
APT	Application Type	Use to limit search to utility patents (not designs)
AN	Assignee Name	Use to limit search to a particular company
ISD	Issue Date (grant date - can specify range)	Use to restrict search to certain time period
ICL	International Classification (IPC symbol)	Use to restrict search to certain technology area

Throughout the study, the search parameter ‘Application Type’ was used to limit the searches to utility patents as these best represent technological inventions.

The search parameter ‘Assignee Name’ was used to limit the search to a particular company. Having selected the set of companies for the study, difficulties were encountered in constructing appropriate ‘Assignee Name’ search terms to capture all the relevant patents for a particular company. The difficulties here centred on requiring a detailed knowledge of each company’s history, to identify names of subsidiaries and previous acquisitions. These challenges are discussed in more detail in Chapter Four.

The search parameter ‘Issue Date’ was used to specify the time range for each search. Time constraints made it unfeasible to evaluate the entire patent portfolios of BP, Amoco and their competitors across a wide time frame. Consequently, the study was focused on the period immediately prior to the BP Amoco merger (completed December 1998). The rationale behind this decision was to obtain a ‘snapshot’ of the companies’ technology profiles and the competitive environment in the period preceding the merger. Additionally, searching on this time frame allowed sufficient time for the patents to have accumulated citations so that a meaningful citation count analysis could be performed. Initial searches were conducted for the period 1993-1998 to obtain an overview of each company’s patent portfolio. Data searches for the patent ‘quality’ analyses focused on the period 1996-1998. The volume of data required for these more detailed analyses made it unfeasible to examine a longer time span in the current study.

One feature of the current study is that the US patent issue date (grant date) was used to define the time period studied. This approach has the advantage that the patents studied had all passed the initial quality filter of examination by the USPTO. A disadvantage of this approach is that the grant date does not necessarily reflect the age of the technology disclosed in the patent. This is due to differences in timings for filing international patent applications and because of the variable time taken for the patent examination procedure. Alternative approaches to define the search period are discussed in Chapter Four.

The search parameter ‘International Classification’ was used to specify the technology area for a particular search. All technology area searches were conducted at the IPC ‘class’ level (e.g. ‘B01’) as this was the broadest level possible in the USPTO database. This type of search returned all patents that contained the specified IPC class anywhere in their International Classification list. It was not possible to limit the search to patents with that IPC symbol as their primary (first listed) classification.

Initial searches covered all the IPC sections (IPC symbols A to H) to map the entire technology spectrum for each company and identify the most highly patented areas. Patent ‘quality’ analysis (via bibliographic information) then focused on two of the most highly patented areas identified in the initial searches. These two areas were IPC class ‘C07’ (defined as, “organic chemistry”) and IPC class ‘C08’ (defined as, “organic macromolecular compounds: their preparation or chemical working-up; compositions based thereon”).

3.7 Data Collection and Analysis

The USPTO database searches typically returned a list of patent numbers matching the search criteria. For the patent ‘quantity’ analyses, the number of ‘hits’ on each search results list was copied to a Microsoft Excel spreadsheet for subsequent tabulation. No detailed statistical analyses were conducted on these data as the purpose of the patent 'quantity' searches was to provide an overview of each company's patent portfolio.

More detailed data collection and analyses were utilised for the patent 'quality' assessments. Citation analysis was conducted on all patents containing IPC class 'C07' or 'C08' granted to the selected companies during 1996-1998. Each patent identified in these searches was reviewed on screen to extract the principal IPC class and the 'Referenced By' hyperlink was used to generate a list of later patents which referenced the patent in question (citations). The patent number, principal IPC class and number of citations were recorded in Microsoft Excel spreadsheets on a per company and per year basis. These results were grouped and tabulated to display the citation profile of each company. No additional statistical analyses were conducted due to the highly skewed distribution of the data (with the vast majority of patents receiving fewer than five citations).

The additional bibliographic analyses – citation linkage, technology cycle time and science linkage – required an even greater volume of data than the citation analysis. Consequently, these analyses were conducted on only a sub-set of the patents from the citation analysis. Specifically, patents granted during 1997 with 'C08' as their primary IPC class were selected. IPC class 'C08' was selected because the polymer chemistry defined by this class has a strong scientific basis and was considered most likely to highlight any differences in technological strength between the companies. The spreadsheets generated for the citation analysis were electronically sorted to identify and extract the relevant sub-set of patents for the bibliographic analyses.

Bibliographic information for this sub-set of patents was obtained via patent number searches of the Delphion website (http://www.delphion.com). The Delphion database was selected for speed and ease of data extraction. The Delphion search output provided a summary table listing the US patents referenced, together with their assignees and grant year. A list of 'other' references (including science papers) was also included in the Delphion output. To extract the corresponding patent reference information from the USPTO website would require the download of each individual patent referenced and then extracting the required information from the front page. These bibliographic data, listed in Table 3.2, were recorded in Excel spreadsheets for subsequent analyses. These analyses are described in detail in Chapter Six.

Table 3.2 Patent Data Collected for Bibliographic Analyses

Patent Information	**Rationale**
US granted patent number	Unique reference for patent
Number of science references cited	Needed for patent 'quality' analysis – links to scientific research (science linkage)
Date of each US patent reference cited	Needed for patent 'quality' analysis – speed of innovation (technology cycle time)
Assignee of each US patent reference cited	Needed for patent 'quality' analysis - map citation between companies (citation linkage)

The final aspect of the data analysis involved a comparison of the patent portfolios of BP and Amoco to explore any technology basis to the company merger decision. The quantity and quality of the companies' patents were compared using the data generated earlier in the study. In addition, the primary IPC class and number of citations were recorded for all BP and Amoco patents granted during 1996-1998. These data were tabulated to explore the technology focus areas for both companies and to explore which technology areas received the highest citation counts.

A brief literature review of the chemical industry press and UK broadsheet newspapers was conducted to investigate how business analysts viewed the BP Amoco merger at the time of negotiation. The aim of this review was to explore what reasons for the merger were identified at the time and if technology synergy was one of the factors identified.

3.8 Reliability and Validity

A common feature of positivistic studies is that reliability is high but that validity can be low (Hussey and Hussey, 1997, p.57). The reliability of data collection from the USPTO database was tested during the pilot study. Identical searches were conducted on different days and at different times of day and found to produce identical search results. The reliability of the Delphion patent database for collection of bibliographic data was also tested. Identical searches conducted at different times produced identical results which also matched equivalent searches using the USPTO database.

The validity of patent statistics as an indicator of innovation has been the subject of much debate, as discussed in Chapter Two. Earlier studies investigating the validity of patent bibliographic analysis as an indicator of technology quality are of particular relevance to the current study. In general, these previous studies found a positive correlation between citation counts and the technological significance of individual patents (see Section 2.9). During the current study, an opportunity arose to test the validity of citation counts as an indicator of a patent's 'significance' within the petrochemicals industry. A detailed description of the test design can be found in Chapter Five but, in essence, this involved a comparison of patent citation counts with an expert grading of the patents' commercial significance. The outcome of this test is discussed in Chapter Five.

CHAPTER FOUR

PATENT QUANTITY & TECHNOLOGY AREA ANALYSIS

4.1 Chapter Four Overview

This Chapter presents the findings of the initial phase of patent analysis for the selected group of companies. The objective of this phase was to obtain an overview of the companies' patent portfolios in terms of magnitude and technology areas. The results of this patent quantity analysis and technology area analysis (as represented by IPC categories) are summarised and discussed. The Chapter also reviews the challenges and limitations of these patent analysis techniques that were identified during the course of the study.

4.2 Chapter Four Data Collection

Patent quantity data were collected from the USPTO website. The search parameters 'Application Type' and 'Issue Date' were used to limit the search to utility patents granted during the period of interest. The company names were defined using the 'Assignee Name' parameter. In addition, the 'International Classification' parameter was used to limit the search to a particular technology area, using the three character IPC class symbols. The search results were copied to a Microsoft Excel spreadsheet for tabulation and analysis.

4.3 Results and Discussion – Patent Quantity Analysis

Table 4.1 summarises the results of the patent quantity analysis. The results indicate that the companies studied fall into four main groups. BASF is the leading company in terms of number of US patents granted, with approximately twice as many patents as any of the other companies studied. Dow Chemical, Exxon, Shell and Mobil all received a similar number of patents and form the next grouping. Amoco, BP and Union Carbide form a similar cluster. The joint ventures Montell and Targor received the least number of patents.

Table 4.1 Number of US Patents Granted During Period 1993-1998

	Time Period		
Company	**1993-1998**	**1993-1995**	**1996-1998**
Amoco	483	287	196
BASF	2729	1329	1400
BP	303	166	137
Dow Chemical	1382	842	540
Exxon	1385	747	638
Mobil	1094	769	325
Montell	96	12	84
Shell	1001	610	391
Targor	14	0	14
Union Carbide	336	207	129
All Patents	*670759*	*301512*	*369247*

There are several possible explanations for the large number of BASF patents versus the other companies. The current analysis considers counts of granted patents but does not include any maintenance statistics. It is possible that BASF has a policy to file patents wherever possible but to discard the least significant when maintenance fees become due. This type of approach is resource-intensive but acts as a deterrent to competitors. BASF's patent strategy may also be influenced by the specific provisions in German law regarding ownership of employees' inventions. According to the German Employee's Invention Act, if an employer fails to claim an employee's invention, then ownership of the invention remains with the employee. This may act as an incentive for companies such as BASF, with a significant German R&D organisation, to seek patent protection wherever possible.

The observation that Exxon and Shell have leading patent counts amongst the oil companies is not surprising, given their clear industry leadership at that time (Rhodes and Crow, 1998). However, Mobil's US patent portfolio is unexpectedly large. Based on company stock market values, Mobil's profile would be expected to be more similar to that of BP or Amoco (Hoover's 1998a, 1998b). The differences between the companies may be due to differing approaches towards patent portfolio management and could be investigated further via a study of patent renewal activity. Several factors may contribute to the lower patent counts for Montell and Targor. Firstly, these joint ventures were formed during the period studied and so the statistics may not be representative of 'full capacity' patenting. Further considerations are that the joint ventures are considerably smaller than the other organisations studied and they were established to focus on very specific technology areas.

Over the period 1996-1998 there was approximately a 20% increase in the total number of US patents granted versus the period 1993-1995. However, the opposite trend was observed within the group of companies studied. The reasons for this decrease are not immediately apparent and it would be interesting to investigate whether changes in R&D expenditure could account for decreased patenting activity. It has been reported (Petrash, 1998) that Dow Chemical modified their patent management strategy during this period. The company placed an increased focus on the quality of patent applications and this may contribute to the reduced volume of granted patents. Montell and Targor are two exceptions to this downward trend, probably because these joint ventures were formed during the period studied and so their statistics represent start-up patenting activity. BASF also showed a small increase in patent volume, consistent with a policy to file patent applications wherever possible, as discussed earlier in this Section.

4.4 Results and Discussion – Technology Area Analysis

Table 4.2 summarises the results of the technology area searches (the results for the individual periods 1993-1995 and 1996-1998 are tabulated in Appendix A2). The aim of this analysis was to compare the technological diversity of the companies. All of the companies studied had the greatest concentration of patents in IPC Section C (Chemistry; Metallurgy) and these proportions (typically 60%) were considerably higher than the statistics for all patents granted during the same period (ca. 15%). These statistics suggest that the oil companies have focused their patenting efforts on their petrochemical businesses rather than their upstream activities (oil and gas exploration and production) or their downstream operations (refining and marketing).

Table 4.2 Technology Area Distribution During Period 1993-1998

	IPC Section							
Company	**% A**	**% B**	**% C**	**% D**	**% E**	**% F**	**% G**	**% H**
Amoco	2.4	17.7	55.5	1.0	5.4	2.1	9.2	6.6
BASF	11.3	13.7	65.1	5.0	0.2	0.7	3.5	0.5
BP	-	21.6	72.5	0.9	0.6	0.9	3.2	0.3
Dow Chemical	5.0	23.0	60.0	2.4	0.7	1.4	6.0	1.5
Exxon	0.4	16.3	68.5	0.9	1.9	1.6	9.4	0.8
Mobil	1.4	24.2	59.9	0.1	8.9	1.9	3.3	0.3
Montell	-	25.9	62.0	8.3	-	1.9	1.9	-
Shell	0.8	12.8	64.9	1.1	11.1	3.4	5.0	1.0
Targor	-	10.5	89.5	-	-	-	-	-
Union Carbide	2.7	21.8	69.8	1.9	-	0.3	1.6	1.9
All Patents	*15.6*	*19.6*	*14.9*	*1.4*	*2.7*	*8.2*	*20.9*	*16.8*

%Y = % Occurrence of IPC Section Y

(a description of this calculation is provided in Appendix A2)

IPC Sections

Section A Human Necessities

Section B Performing Operations; Transporting

Section C Chemistry; Metallurgy

Section D Textiles; Paper

Section E Fixed Constructions

Section F Mechanical Engineering; Lighting; Heating; Weapons; Blasting

Section G Physics

Section H Electricity

In addition to the overall concentration in IPC Section C, some differences in technology distribution were observed between the companies. Amoco's patents contained the broadest spread across IPC sections, with a high concentration in IPC Section H (Electricity) versus the remainder of the group. BASF also showed a broad distribution, with a higher concentration in IPC Section A (Human Necessities) than the other companies. In contrast, Montell and Targor's patents were heavily concentrated in IPC Section C (Chemistry; Metallurgy) and Section B (Performing Operations; Transporting) with Montell showing an additional peak in Section D (Textiles; Paper). This reflects these companies' specific focus on polypropylene technology (Robinson, 2000).

Shell and Mobil both exhibited a relatively high concentration in IPC Section E (Fixed Constructions) due to a cluster of patents in class E21 (earth or rock drilling; mining), probably related to oil production or exploration technology. Both Amoco and Exxon had a relatively high concentration of patents within Section G (Physics). The Exxon peak was attributable to clusters within class G01 (measuring; testing) and class G03 (essentially wave-related imaging techniques), suggesting a commitment to oil exploration technology. It is interesting to note that BP's portfolio is more highly focused than the other oil companies, reflecting a strategic decision to concentrate patent resources in the petrochemicals area (M. Barlow, BP; personal communication; November 2002).

An alternative indicator of technological diversity has been reported by Granstrand (2000, p.360). This involves counting the number of patent classes which contain one or more patents granted to that company during the time period of interest. Table 4.3 summarises these data for the companies in the current study. This indicator may provide additional perspective to the technology distributions calculated in Table 4.2 and the patent counts in Table 4.1. For example, BP and Dow Chemical have a similar percentage distribution within IPC Section B (22-23%) but BP's patents are focused within 9 IPC classes, whereas Dow Chemical's patents span 19 classes. This form of analysis appears well suited to compare the technology focus areas of companies and, as such, is investigated further in Chapter Seven.

Table 4.3 Technology Diversity During Period 1993-1998

	Number of Different IPC Classes Listed (Grouped by Section)								
Company	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**Total**
Amoco	4	10	9	5	3	6	6	3	46
BASF	5	20	16	6	3	9	9	2	70
BP	-	9	10	3	1	1	3	1	28
Dow Chemical	7	19	14	6	3	9	8	2	68
Exxon	4	18	16	5	3	11	5	3	65
Mobil	6	20	10	1	3	8	5	2	55
Montell	-	7	3	2	-	2	1	-	15
Shell	3	13	13	4	3	12	8	3	59
Targor	-	1	2	-	-	-	-	-	3
Union Carbide	2	7	8	4	-	1	3	1	26

See Table 4.2 for a definition of IPC Sections

4.5 Practical Considerations for Patent Quantity and Technology Area Analysis

The first challenge encountered in this study was the definition of appropriate 'Assignee Name' search terms to capture all the relevant patents for a particular company. This is a fundamental concern for any form of company-focused patent analysis. Errors or omissions at this stage compromise the quality of any subsequent analysis of the patent data. Therefore, the discussion below also applies to the more sophisticated analysis techniques used later in this study.

Slight name variants were captured using end-truncation of search terms; for example, 'BP-$' identified both BP Chemicals and BP Solar patents. Leading-truncation was not possible when searching the USPTO database, so searches on both 'dow-chem$' and 'the-dow-chem$' were necessary to identify Dow Chemical patents. A thorough knowledge of the search functions and capabilities of the patent database is therefore a first requirement for this type of study.

Other potential sources of error can only be addressed with a detailed knowledge of company history. One area requiring particular attention is how to treat patents following the acquisition and divestment of operations. For example, in the current study, patents assigned to The Standard Oil Company Cleveland, Ohio have been included in the BP portfolio due to BP's ownership of that organisation. Table 4.4, Table 4.5 and Table 4.6 illustrate how the inclusion of the Standard Oil patents modifies the overall BP company profile versus the BP entities alone. The omission of Standard Oil data would have underestimated the volume of BP's patent portfolio by about 30% and also underestimated the company's technology focus in IPC Section B.

Table 4.4 BP and Standard Oil Number of US Patents Granted (1993-1998)

	Time Period		
Company	**1993-1998**	**1993-1995**	**1996-1998**
BP Entities	230	125	105
Standard Oil	73	41	32
BP Total	303	166	137

Table 4.5 BP and Standard Oil Technology Area Distribution (1993-1998)

	IPC Section							
Company	**% A**	**% B**	**% C**	**% D**	**% E**	**% F**	**% G**	**% H**
BP Entities	-	17.2	76.2	0.4	0.8	1.1	3.8	0.4
Standard Oil	-	35.8	60.5	2.5	-	-	1.2	-
BP Total	-	21.6	72.5	0.9	0.6	0.9	3.2	0.3

Table 4.6 BP and Standard Oil Technology Diversity (1993-1998)

	Number of Different IPC Classes Listed (Grouped by Section)								
Company	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**Total**
BP Entities	-	7	9	1	1	1	2	1	22
Standard Oil	-	5	8	2	-	-	1	-	16
BP Total	-	9	10	3	1	1	3	1	28

This type of linkage between two apparently unrelated assignee names can only be identified with background industry knowledge or by a comprehensive (and time consuming) search of company history. In the current study, the BP/Standard Oil patent consolidation was conducted to illustrate the impact of company acquisition on patent statistics. In the interests of time, no other company consolidations were attempted and this may impact the usefulness of the study results. Granstrand (2000, p.371) recognises the difficulties of company consolidation and notes that treatment of the 'time' element of acquisitions and divestments adds a further complexity to the analysis.

The IPC system provides a relatively straightforward approach to search on technology areas but the interpretation of these patent statistics in an industrial context is more problematic. A first concern is to identify the appropriate level within the IPC hierarchy to collect the patent statistics. The IPC class level (120 categories) is the broadest search level available within the USPTO database. In the current study, IPC class data were consolidated manually to IPC section data to provide a 'low-resolution' overview. Two approaches are available to provide a more detailed technology profile. The first approach is to search at the IPC subclass level (628 categories); the second approach is to combine both technology keyword and IPC search terms. Both of these approaches would be time consuming to conduct manually.

An IPC-based search strategy also assumes that patents have been correctly classified during the examination process; clerical mistakes may introduce further errors into the analysis. Using the USPTO database, a further limitation of an IPC-based search is that it returns any occurrence of that IPC category, regardless of the priority of that category in the patent's classification list. Additional manual sorting is required to extract the primary IPC classification.

A further consideration is how to relate the IPC categories to industrial sectors or product areas. Patents are normally drafted to maximise the monopoly and include as broad a technology area as possible; however, when the invention is commercialised, often only a small sub-section of technology is practised in reality. The Standard Industrial Classification (SIC) system is widely used in the US to present industry statistics (Quick and Baldwin, 2001). However, it is not always straightforward to correlate IPC categories with SIC codes. For example, polymer technology is broadly covered by the industry classification SIC 2821 but only certain subclasses within IPC class C08 fall within that industry definition.

4.6 Chapter Four Conclusions

This empirical study has highlighted the challenges of applying patent analysis in an industrial context. The factors identified here are relevant for all forms of patent analysis and will impact the more sophisticated techniques investigated later in this study.

Company name consolidation is necessary to identify the relevant patent sets and this requires a significant research effort into company history. The IPC system provides the simplest approach to a technology area analysis. However, the transformation of invention-based data (IPC statistics) into application-based categories (industry or product areas) is not trivial.

The current patent analysis has identified several differences between the companies studied. However, the patent analysis in isolation does not explain the reasons underlying these differences. Additional perspective on factors such as company patent policy or home-country patent laws are necessary to develop a more complete understanding of the patent statistics.

The patent quantity and technology area analysis described in this Chapter can provide an indication of a company's technological diversity and its attitude towards patent protection. However, this technique provides no measure of the quality of the patents or the extent to which they are commercially significant. In Chapter Five, this theme of patent quality is explored further, using patent citation analysis.

CHAPTER FIVE
PATENT CITATION ANALYSIS

5.1 Chapter Five Overview

This Chapter presents the results of a patent citation analysis for the selected group of companies within two technology areas. The objective of this phase was to investigate the quality of the companies' patents, assuming the hypothesis underlying citation analysis is valid. Additionally, a small test was conducted to investigate the validity of the technique. The experiment explored the relationship between patent citation counts and the commercial significance of the technology, as assessed by expert graders. The results of this test are reviewed and the implications regarding the validity of patent citation analysis are discussed. The Chapter also reviews the practical challenges of patent citation analysis that were encountered during the study.

5.2 Data Collection – Citation Analysis

Citation data were collected from the USPTO website over a two week period in October 2002. The searches were limited to the period 1996-1998 and to patents containing IPC class C07 (organic chemistry) or IPC class C08 (essentially polymer chemistry). These two technology areas were selected as they were the most highly populated IPC classes in the earlier technology areas analysis (Chapter Four). Once the relevant company patents had been identified, the number of citations was established using the 'Referenced By' hyperlink for each patent. The search results were recorded in Microsoft Excel spreadsheets for tabulation and analysis.

5.3 Results and Discussion– Citation Analysis

Table 5.1 lists the number of patents containing IPC class C08 for the companies of interest and Table 5.2 lists the equivalent information for IPC class C07. Patent quantities in these classes display similar trends to those observed in Chapter Four. BASF has the greatest number of patents, with Dow Chemical, Exxon and Shell

Table 5.1 Number of Patents Containing IPC Class C08 (1996-1998)

	Grant Year			
Company	**1996-1998**	**1996**	**1997**	**1998**
Amoco	27	13	9	5
BASF	463	149	133	181
BP	40	10	17	13
Dow Chemical	214	74	62	78
Exxon	165	52	63	50
Mobil	34	20	7	7
Montell	51	22	16	13
Shell	168	46	54	68
Targor	9	0	0	9
Union Carbide	66	24	19	23

Table 5.2 Number of Patents Containing IPC Class C07 (1996-1998)

	Grant Year			
Company	**1996-1998**	**1996**	**1997**	**1998**
Amoco	63	20	18	25
BASF	444	132	121	191
BP	44	7	16	21
Dow Chemical	98	40	25	33
Exxon	92	25	28	39
Mobil	86	46	20	20
Montell	4	2	1	1
Shell	67	23	16	28
Targor	8	0	0	8
Union Carbide	32	4	4	24

forming the next group. Differences in the relative proportion of patents in IPC class C07 versus IPC class C08 were also observed. BASF, BP and Targor have a similar number of patents in both classes, whereas Amoco and Mobil's patents are focused in IPC class C07. For the remaining companies, IPC class C08 predominates. These differences in patent distribution may be indicative of differences in the importance placed on polymer technology versus more general organic chemistry within the companies studied. This could be explored further through an analysis of the companies' product portfolios.

Table 5.3 and Table 5.4 summarise the number of citations received by each of the companies' patents within IPC class C08. Table 5.5 and Table 5.6 present the equivalent data for IPC class C07. A more detailed breakdown of the citation data is presented in Appendix A3. The general pattern within both data sets is that the vast majority of patents received fewer than ten citations each in the four to six year period following their grant. Only a small proportion of the patents studied have become very highly cited, receiving greater than twenty citations each since grant. The majority of these very highly cited patents fall within IPC class C08.

A simple patent quantity count would suggest that BASF is the leading company within the study for both the C07 and C08 technology areas. However, if citation counts are assumed to represent patent quality, then a different picture emerges. Dow Chemical and Exxon have the largest number of very highly cited patents within the C08 class (Table 5.3), with Targor and BP also performing strongly if this quantity is calculated as a percentage of the company's total patents within that class (Table 5.4). The companies are less well differentiated within IPC class C07. Exxon and BASF have a similar number of patents receiving more than ten citations within the C07 class, with only one Exxon patent receiving more than twenty citations (Table 5.5).

The reasons for the difference in number of very highly cited patents between IPC class C07 and IPC class C08 are not immediately obvious. One possible explanation is that the companies studied may represent the technology leaders within the polymer chemistry area (IPC class C08) and therefore have several very highly cited

Table 5.3 Number of Citations Received (1996-1998 Patents; IPC Class C08)

	Total No.	Number of Patents Receiving Citations		
Company	**Of Patents**	**<10 Citations**	**10-19 Citations**	**20+ Citations**
Amoco	27	26	1	-
BASF	463	445	15	3
BP	40	38	-	2
Dow Chemical	214	191	16	7
Exxon	165	150	10	5
Mobil	34	26	8	-
Montell	51	45	6	-
Shell	168	161	7	-
Targor	9	6	-	3
Union Carbide	66	60	5	1

Table 5.4 Citation Percentages (1996-1998 Patents; IPC Class C08)

	Percentage of Patents Receiving Citations		
Company	**<10 Citations**	**10-19 Citations**	**20+ Citations**
Amoco	96.3	3.7	-
BASF	96.1	3.2	0.6
BP	95.0	-	5.0
Dow Chemical	89.3	7.5	3.3
Exxon	90.9	6.1	3.0
Mobil	76.5	23.5	-
Montell	88.2	11.8	-
Shell	95.8	4.2	-
Targor	66.7	-	33.3
Union Carbide	90.9	7.6	1.5

Table 5.5 Number of Citations Received (1996-1998 Patents; IPC Class C07)

Company	Total No. Of Patents	Number of Patents Receiving Citations		
		<10 Citations	10-19 Citations	20+ Citations
Amoco	63	63	-	-
BASF	444	433	11	-
BP	44	42	2	-
Dow Chemical	98	93	5	-
Exxon	92	82	9	1
Mobil	86	81	5	-
Montell	4	3	1	-
Shell	67	65	2	-
Targor	8	8	-	-
Union Carbide	32	31	1	-

Table 5.6 Citation Percentages (1996-1998 Patents; IPC Class C07)

Company	Percentage of Patents Receiving Citations		
	<10 Citations	10-19 Citations	20+ Citations
Amoco	100.0	-	-
BASF	97.5	2.5	-
BP	95.5	4.5	-
Dow Chemical	94.9	5.1	-
Exxon	89.1	9.8	1.1
Mobil	94.2	5.8	-
Montell	75.0	25.0	-
Shell	97.0	3.0	-
Targor	100.0	-	-
Union Carbide	96.9	3.1	-

patents. However, a different set of companies (not included in the current study) might be leaders within the general organic chemistry area (IPC class C07) and so there are fewer significant patents within the current data set. A second possible explanation is that citation counts are generally lower within IPC class C07 than within IPC class C08. An examination of citation counts for all patents within these two technology areas would be required to test this hypothesis.

5.4 Practical Considerations for Patent Citation Analysis

Patent citation analysis is subject to many of the methodological challenges described in Chapter Four. Difficulties with company name consolidation and correlation of patent and industry classifications can impact both data collection and interpretation. As noted in Chapter Four, patent analysis in isolation can identify but not explain differences between the companies studied. Additional perspective on factors such as company product areas and market share are required for a more comprehensive understanding of the patent statistics.

Assuming that citation counts are a valid indicator of patent quality, the time delay for a patent to become highly cited may limit the industrial usefulness of citation analysis. The technique appears better suited as a retrospective measure rather than as an early indicator of landmark developments. It would be interesting to investigate how quickly key patents become highly cited and so estimate the 'response time' of citation analysis.

It is relatively straightforward, though time-consuming, to extract citation counts from the USPTO database. In the current study, retrieval of citation counts took approximately one minute per patent. A key limitation of the technique is that data normalisation is necessary to perform a detailed statistical analysis (Narin *et al*, 1984), which is not feasible to conduct manually. A small-scale investigation, such as the current study, allows a comparison of general trends within the group of companies studied but is insufficient to measure differences between technology areas or between industries.

For example, in the current study, it was assumed that differences in patent age (in this case, four to six years) were negligible when identifying very highly cited patents (>20 citations). This appears a reasonable assumption but highlights that only crude comparisons can be made within a small-scale study. A more in-depth analysis would require normalisation of citation counts versus a larger data set to identify average citation rates and provide a more sensitive measure of what constitutes a highly cited patent.

Finally, the question of the validity of citation counts as a measure of patent quality remains. The data patterns in the current analysis are consistent with citation counts acting as a filter but, taken in isolation, they do not confirm this is a filter of the patents' technical or commercial significance. The remainder of this Chapter focuses on this question of validity and describes an examination of the correlation between patent citation counts and commercial significance within the petrochemicals area.

5.5 Introduction – Testing the Validity of Citation Analysis

The citation analysis described earlier in this Chapter identified a small group of very highly cited patents, receiving over twenty citations each over a four to six year period. The hypothesis underlying the patent citation technique would suggest that these patents are very highly cited because they are of a high quality and represent significant developments within this technology area. A small experiment was designed to investigate this hypothesis further. The test involved the comparison of citation counts with expert grading of the patents' commercial significance. The link between citation counts and commercial significance may be somewhat more tenuous than the link between citation counts and technological significance (Granstrand, 2000, p.164). However, commercial significance was chosen as the 'quality' parameter for this study as it provides an end-point measure of a patent's value. The following Sections describe the design of the experiment, the test findings and the implications for the patent citation technique.

5.6 Data Collection – Testing the Validity of Citation Analysis

A group of ten very highly cited patents (greater than twenty citations) was identified from the previously described citation analysis. In an attempt to focus the technology area, the selected 'test' patents all belonged to IPC subclass C08F as their primary IPC classification. (IPC subclass C08F is defined as "macromolecular compounds obtained by reactions only involving carbon-to-carbon unsaturated bonds"). For each 'test' patent a corresponding 'control' patent (receiving less than six citations) was then selected. Each 'control' patent belonged to IPC subclass C08F as their primary IPC classification to minimise technology differences between the 'test' and 'control' sets. Each 'control' patent was selected from the same assignee as the corresponding 'test' patent to minimise any inter-company effects. Additionally, the 'control' patent was selected to be the patent having the nearest grant date to the corresponding 'test' patent once the other criteria (assignee, IPC subclass, number of citations) had been met. This was done in an attempt to exclude any time-related effects from the test.

Table 5.7 lists the set of 'control' and 'test' patents used in this test. The chronological list of twenty patent numbers was provided to the expert graders three working days in advance of the grading meeting with no note of the number of citations. The expert graders were three experienced patent attorneys and analysts employed by BP with specialist knowledge of the petrochemicals area. At the grading meeting, the team of graders was asked to answer for each patent, "Is this patent commercially significant?" (Yes/No response). The question "Why is this patent commercially significant?" was also asked for the patents rated as being 'commercially significant' in the first question.

During the grading session, it became apparent that several of the 'C08F' patents fell outside the graders' areas of expertise and therefore should be excluded from the test. To replace these eight data points, four additional 'reserve' patents (front page and claims) were reviewed by the graders at the grading session. The additional patents were selected according to the criteria described above.

Table 5.7 Patents Used in Validity Test of Citation Analysis

'Test' Patents

Patent No.	Year	Assignee	No. Citations	1st IPC Code
5703187	1997	Dow Chemical	64	C08F 210/02
5643847	1997	Exxon	37	C08F 004/64
5542459	1996	BASF	34	C08F 251/00
5770753	1998	Targor	32	C08F 004/642
5541270	1996	BP	31	C08F 002/34
5527752	1996	Union Carbide	27	C08F 004/642
5627248	1997	Dow Chemical	24	C08F 002/00
5552497	1996	BASF	24	C08F 283/04
5486632	1996	Dow Chemical	24	C08F 004/643
5786432	1998	Targor	23	C08F 004/642
5539068	1996	Dow Chemical	23	C08F 004/643
5840644	1998	Targor	22	C08F 004/642

'Control' Patents

Patent No.	Year	Assignee	No. Citations	1st IPC Code
5700887	1997	Dow Chemical	0	C08F 004/46
5648438	1997	Exxon	1	C08F 002/14
5548037	1996	BASF	1	C08F 283/04
5763542	1998	Targor	1	C08F 004/42
5545378	1996	BP	0	C08F 002/34
5510433	1996	Union Carbide	3	C08F 002/34
5629396	1997	Dow Chemical	0	C08F 226/06
5556918	1996	BASF	1	C08F 008/30
5484862	1996	Dow Chemical	5	C08F 002/02
5792819	1998	Targor	4	C08F 004/44
5536797	1996	Dow Chemical	5	C08F 004/64
5852142	1998	Targor	0	C08F 004/64

5.7 Results and Discussion – Testing the Validity of Citation Analysis

Figure 5.1 summarises the results of the patent grading exercise. The Chi squared (χ^2) test method was used to analyse the experimental results (Hussey and Hussey, p.232). The null hypothesis (H_0) and alternative hypothesis (H_1) for this analysis were as follows:

H_0: The number of citations received by a patent is independent of the commercial significance of the patent.

H_1: The number of citations received by a patent is associated with the commercial significance of the patent.

Using the formula:

$$\chi^2 = \Sigma \frac{(O - E)^2}{E}$$

Where: O = Observed (actual) frequencies
E = Expected (hypothesised) frequencies

the calculated value of χ^2 in the current study is $\chi^2 = 4.5$. Using χ^2 tables, the 5% critical value at one degree of freedom = 3.84. Therefore, as the calculated value is greater than the critical value, there is evidence to reject the null hypothesis. The test results support the hypothesis that citation counts are positively associated with the commercial significance of the patent.

Figure 5.1 Comparison of Patent Citation Counts and Expert Grading

Commercially Significant?	<6	>20
Yes	1 Patent (6.25%)	6 Patents (37.5%)
No	6 Patents (37.5%)	3 Patents (18.75%)

Citation Counts

Ideally, to carry out a χ^2 test, the expected frequency in each class should be at least five (Kanji, 1993). However, due to the unsuitability of some of the test patents, this could not be achieved in the current experiment. Some caution should therefore be exercised in interpreting the test results. However, the experiment does indicate that there is some validity underlying the use of citation counts as an indicator of a patent's significance.

The majority of the patents rated as commercially significant by the expert graders were considered significant because they formed part of a group of important patents for the assignee. The highly cited patents were not the 'core' patent that formed the foundation for the technology area; rather they were 'supporting' patents that extended the area of invention. This method of consolidating and extending protection has been called patent 'clustering' (Harrison and Rivette, 1998).

5.8 Are Commercially Significant Patents Highly Cited?

The validation experiment described in Sections 5.5 to 5.7 suggests that citation analysis can be reasonably successful in predicting the commercial significance of the technology disclosed by the patent. A small follow-up test was conducted to explore whether the converse is true – Are Commercially Significant Patents Highly Cited?

The BP expert graders produced a list of ten US patents they considered to be highly significant in the polyethylene polymer area. The number of citations received by each of these patents was established via the USPTO website, using the 'Referenced By' hyperlink. Table 5.8 summarises the citation count results.

Previous studies involving multiple technology areas have reported that the average US patent receives about five citations in the first six years following grant (Narin, 2000). If this is approximated to 'one citation per year after grant', then all the patents in Table 5.8 should be considered highly cited. It is interesting to note that the majority of these 'milestone' patents also received substantially more citations than the highly cited patents in Table 5.7. This suggests that it may be possible to

Table 5.8 Citation Counts for Commercially Significant Patents

Patent No.	Year	Assignee	No. Citations	1st IPC Code
#781	1997	Company A	70	C08F 210/02
#272	1994	Company A	280	C08F 010/04
#632	1993	Company A	340	C08F 210/08
#083	1992	Company A	120	C08F 004/64
#630	1994	Company B	62	C08F 004/642
#023	1989	Company B	19	*G08F 002/34
#993	1985	Company B	74	C08F 002/34
#008	1994	Company C	150	C08F 004/602
#834	1991	Company C	224	C08F 004/642
#165	1989	Company C	202	C08F 004/64

Citation counts collected 10th December 2002. Patent numbers and company names have been concealed

* Note subclass G08F is not a valid IPC category. From the patent subject matter, it appears that the correct code should be C08F.

further sub-divide highly cited patents into 'core' technology (extremely highly cited) and 'supporting' technology (highly cited). This hypothesis could be explored further in a follow-up study.

A final observation from this data set is that misclassification of IPC codes can occur (subclass G08F does not exist). The patent assigned this misclassification received substantially fewer citations than the remainder of the group, possibly because it would not be identified by later patent searches based on IPC technology class. This highlights that administrative errors can impact the quality of patent searches and subsequent data analysis.

5.9 Chapter Five Conclusions

In the current study, the comparison of citation counts and expert grading has indicated that citation analysis may provide one route to identify commercially significant patents. This supports the use of citation data to measure and compare the quality of companies' patent portfolios. The current, small-scale analysis was able to identify trends within the companies studied. However, some form of automated data collection would be required to handle the volume of data involved in a full scale statistical analysis.

In an industrial context, this suggests that citation analysis could be used to produce 'league tables' of competitor companies or to evaluate the significance of new technologies. However, a key factor which may limit its usefulness for competitor analysis is the time lag for patents to become highly cited. For example, if a breakthrough technology is commercialised rapidly, then market share information may provide a direct indication of its impact, before its importance becomes evident in the patent citation statistics.

CHAPTER SIX

PATENT BIBLIOGRAPHIC ANALYSIS

6.1 Chapter Six Overview

This Chapter presents the results of the third phase of patent analysis for the selected group of companies. The objective of this phase was to explore the value of measures based on bibliographic information as indicators of technology quality. The results of this analysis of citation linkage, technology cycle time and science linkage (as defined in Chapter Three) are summarised and discussed. The Chapter also describes the challenges and limitations of these analysis techniques that were encountered during the course of the study.

6.2 Data Collection – Bibliographic Analysis

The bibliographic analyses were conducted only on patents granted during 1997 with IPC class C08 as their primary IPC category. The relevant patents were identified by electronic sorting of the spreadsheets generated during the Chapter Five analysis. No Targor patents met these criteria and so Targor was not included in the analysis. Bibliographic information for the selected group of patents was obtained via patent number searches of the Delphion website (http://www.delphion.com), as discussed in Section 3.7. The bibliographic information recorded for each patent was the grant year and assignee of each US patent reference (to calculate the technology cycle time and to summarise citation linkages) and also the number of science papers referenced (to calculate the science linkage).

For the citation linkage analysis, the lists of US patent assignees referenced were amalgamated and counted for each company of interest. The technology cycle time analysis was conducted in two stages. Firstly, the median age of the US patent references was calculated for each individual patent and tabulated on a per-company basis. Next, the mean value of this table was calculated for each company to obtain an 'average' technology cycle time, using the Descriptive Statistics function within Microsoft Excel. The science linkage analysis involved recording the number of science papers referenced by each individual patent for each company. The mean number of science references was then calculated on a per company basis using the Descriptive Statistics function within Microsoft Excel.

6.3 Results and Discussion – Citation Linkage

The majority of the companies studied referenced their own patents most frequently (Table 6.1). Two factors have been identified that may contribute to this observation. The first factor is that companies will be most familiar with their own patent applications and therefore may have a higher tendency to reference them in their submissions to the Patent Office. The second factor is that companies may file several patents in closely related technology areas and therefore their own patents are the most relevant prior art to cite. It is interesting to note that the companies with the lowest self-referencing rates, Amoco and Mobil, subsequently became subject to merger activity, with BP and Exxon respectively. A tentative hypothesis is that Amoco and Mobil lacked 'critical mass' in this technology area (hence the low rates of self-referencing) and this may have contributed to the merger decision.

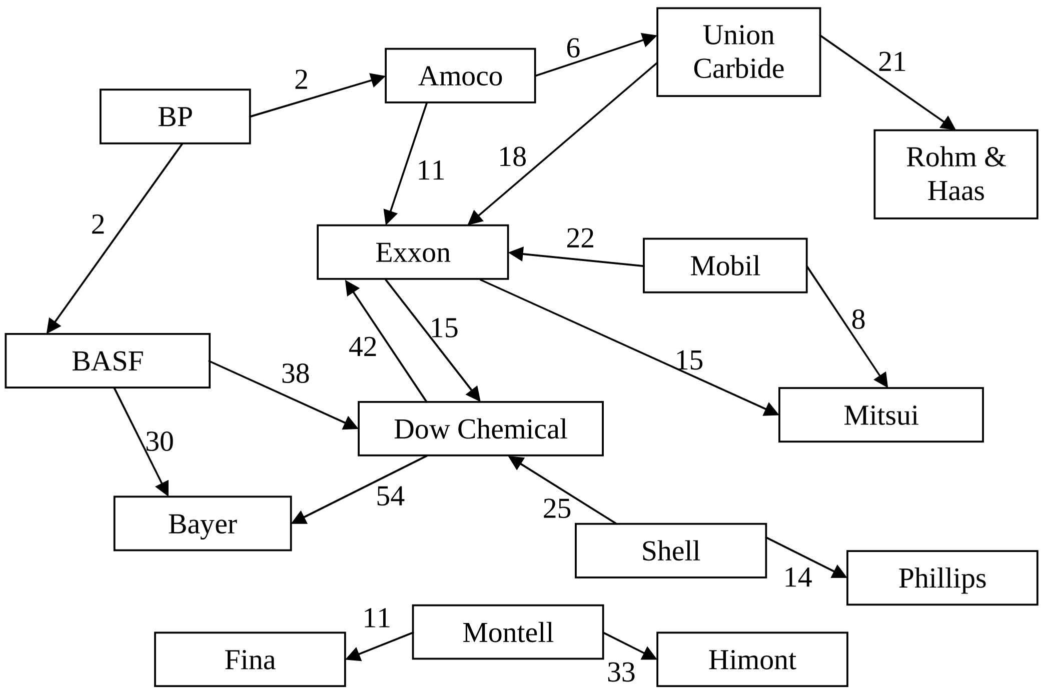
Table 6.1 Self-Referencing Statistics (1997 Patents; C08 Primary IPC Class)

Company	No. Patents Analysed	No. US Patent References	No. Self-References	% Self References
Amoco	8	45	2	4.4
BASF	123	695	150	21.6
BP	15	56	7	12.5
Dow Chemical	62	898	192	21.4
Exxon	58	581	198	34.1
Mobil	3	95	3	3.2
Montell	15	155	2*	1.3*
Shell	52	431	131	30.4
Union Carbide	18	318	53	16.7

*Only references made by Montell to Montell patents are included here

Figure 6.1 summarises the key inter-company citation links identified in the current study. The hypothesis underlying the citation linkage technique is that companies that are technological leaders will be highly cited by their peers. If this is valid, then the current analysis indicates that Exxon and Dow Chemical are leaders amongst the companies studied, being highly referenced by several of their peers.

Figure 6.1 Citation Linkage Map (1997 Patents; C08 Primary IPC Class)



Note:

Only top two referenced companies are shown, self-references are not included.

Arrows indicate direction of referencing; numbers represent number of references made.

The citation linkage analysis introduced several additional companies, such as Mitsui, to the study. It would be interesting to conduct a patent citation analysis on these companies to investigate whether specific highly cited patents are responsible for their appearance in the analysis. A further observation is that the joint venture Montell makes very few references to its Shell parentage but is more strongly linked to Himont, a wholly owned subsidiary of Montedison, the other joint venture partner

(Federal Trade Commission, 1995). This suggests that Montell's technology development may be based mainly on Montedison's input to the joint venture.

When collecting the bibliographic data, there appeared to be some differences between companies in terms of the number of references cited. To investigate this further, the mean number of US patent references cited was calculated on a per company basis (Table 6.2). These data should be interpreted cautiously because the sample represents only a small proportion of the companies' entire patent portfolios. However, it appears there may be some significant differences between companies in terms of the number of references cited (Figure 6.2).

The 'References Cited' section that appears on a US patent is based upon a list of relevant prior art supplied by the applicant but the contents of the final list remains the responsibility of the patent examiner (Albert *et al*, 1991). The current analysis suggests that companies may have different interpretations of what constitutes 'relevant' prior art and these differences may persist through to the granted patent document. If this hypothesis is correct, then it may form another potential source of error in interpreting patent statistics. For example, if a company has a high tendency towards self-referencing (Table 6.1) and also submits long prior art lists (Table 6.2), then the combined effect may be an increased likelihood that the company's patents will become highly cited. A more in-depth analysis would be required to investigate this further. An interesting starting point would be to recalculate the citation statistics in Chapter Five with all instances of self-referencing removed.

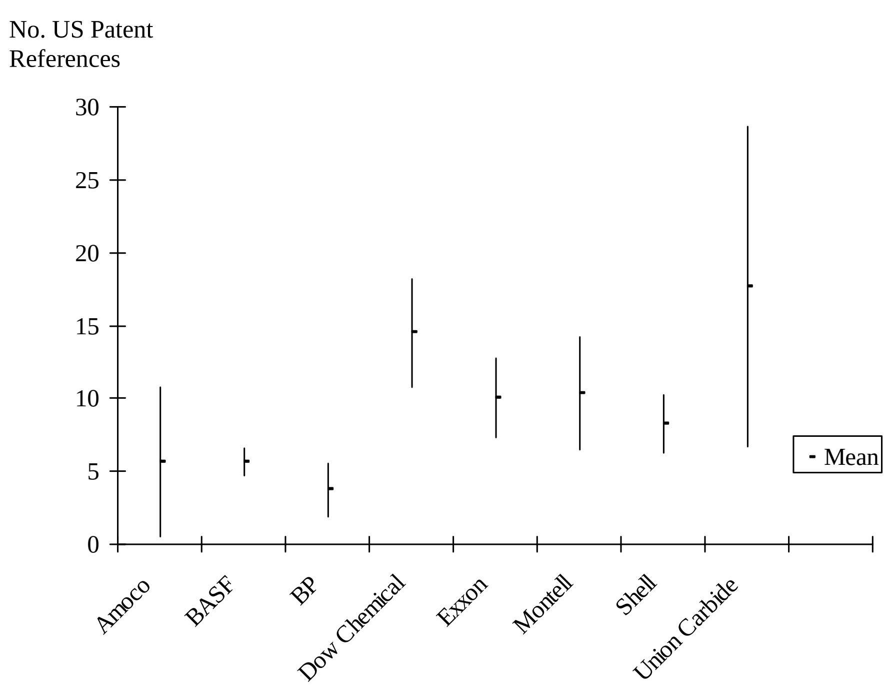
6.4 Results and Discussion – Technology Cycle Time

Table 6.3 summarises the results of the technology cycle time (TCT) calculations. The companies all show similar technology cycle times, ranging from about 9 to 14 years and there appear to be no significant differences between the companies. This suggests that technology within the polymer area was relatively slow moving during the period studied (Narin, 2000). It is possible that differences between the companies would become apparent if a wider time frame or a broader range of technologies were investigated.

Table 6.2 Number of US Patents Cited (1997 Patents, C08 Primary IPC Class)

Company	Mean No. US Patent References Listed per Patent	Confidence Level (95%)	Range (Min-Max)	No. Patents Analysed
Amoco	5.63	5.15	1-20	8
BASF	5.65	0.94	1-26	123
BP	3.73	1.85	0-11	15
Dow Chemical	14.48	3.72	1-68	62
Exxon	10.02	2.69	0-44	58
Mobil	31.67	67.59	14-63	3
Montell	10.33	3.85	1-25	15
Shell	8.29	1.99	1-35	52
Union Carbide	17.67	10.97	0-80	18

Figure 6.2 Confidence Intervals for Number of US Patents Cited



Note: 1997 patents with C08 as primary IPC class; Mobil data not included.

Table 6.3 Technology Cycle Time (1997 Patents; C08 Primary IPC Class)

Company	Mean TCT (years)	Confidence Level (95%)	Range (Min-Max)	No. Patents Analysed
Amoco	12.2	5.5	2-23	8
BASF	10.7	1.2	1-30.5	122
BP	14.3	5.3	3-28	13
Dow Chemical	10.1	1.1	1.5-23	62
Exxon	9.2	1.4	2-22	57
Mobil	10.2	9.0	6-12.5	3
Montell	11.7	4.9	3-30	15
Shell	10.8	1.8	1.5-33.5	52
Union Carbide	8.9	2.3	3-13	17

The use of the median age of cited patents appears reasonable to avoid distortion of the data by one or two very old references. In the current analysis, the median age of the patent references was calculated at the time of the patent's grant. However, it may be more appropriate to calculate the median age of the references at the time of the patent application, to minimise any variability introduced by delays in the examination procedure.

6.5 Results and Discussion – Science Linkage

Table 6.4 summarises the results of the science linkage calculations. The mean number of science references per patent ranges from 0 to 4 for the companies studied. The pattern of the science reference data is rather skewed, with the majority of patents citing fewer than 5 science references but with a small sub-set referencing over 20 science papers. It is interesting to note that several of the companies that tended to produce the longest patent reference lists (Table 6.2) also tended to make many science references. Again, this may reflect different company attitudes towards the submission of prior art lists to the Patent Office.

Table 6.4 Science Linkage (1997 Patents; C08 Primary IPC Class)

Company	Mean	Range	No. Patents Analysed
Amoco	0.75	0-4	8
BASF	0.09	0-3	123
BP	0.67	0-7	15
Dow Chemical	2.69	0-28	62
Exxon	1.90	0-19	58
Mobil	2.00	0-3	3
Montell	3.47	0-29	15
Shell	0.48	0-14	52
Union Carbide	0.33	0-2	18

The definition of what constitutes a ‘science reference’ introduced an element of subjectivity into the linkage analysis. For the purposes of this study, only references to ‘academic’ science journals were included. However, the boundary between ‘academic’ and ‘industry’ journals is rather grey. Similarly, the classification of conference presentations is another potential source of variability in the data.

6.6 Practical Considerations for Bibliographic Analysis

The bibliographic analysis techniques described in this Chapter are extremely time consuming to conduct manually, taking several minutes per patent to extract the bibliographic information. Some form of automated data collection would be required to study several companies over a moderate time span or a range of technology areas. This involves the same challenges of data normalisation that were discussed in Chapter Five. Similarly, the fundamental concerns of company name consolidation and technology classification also affect these analysis techniques.

The current study also raises concerns regarding the usefulness of these bibliographic techniques in an industrial context. Citation linkage analysis may have some value as a route to visualise technological leadership but the technique is resource-intensive. There is also likely to be a time lag to establish inter-company referencing when a new company enters a technology area, limiting the ability of the technique to provide rapid feedback. Technology cycle time and science linkage calculations are also time consuming and the interpretation of results as a ‘quality’ indicator is less obvious.

The observed trend of inter-company differences in the volume of ‘References Cited’ may also affect the robustness of these analysis techniques. Clearly, a more in-depth analysis would be required to confirm this trend and to explore other factors such as inter-examiner variability. However, if the trend is confirmed, it could introduce distortions into inter-company patent comparisons, including citation count statistics (Chapter Five).

6.7 Chapter Six Conclusions

This small-scale investigation has highlighted that patent bibliographic analysis is extremely resource-intensive to conduct manually. Automated data collection would be required to conduct an analysis of modest size. The current study has also struggled to clarify the usefulness of bibliographic analysis in an industrial context. The citation linkage technique may have some value as an indicator of technological leadership but the applications of technology cycle time and science linkage as ‘technology quality’ indicators are less clear.

From a methodological point of view, the classification of science references introduces an element of subjectivity into the science linkage analysis. The data collected in the current study also suggest that there may be significant inter-company differences in the volume of the ‘References Cited’ list. This raises further concerns regarding the suitability of patent-based bibliographic techniques to make comparisons between companies.

CHAPTER SEVEN

TECHNOLOGY FIT OF MERGER CANDIDATES

7.1 Chapter Seven Overview

This Chapter presents the results of a patent analysis to compare the technology profiles of BP and Amoco in the period immediately prior to their merger (end 1998). The objective of this phase was to investigate how patent statistics could assist in a merger analysis, particularly to measure the 'technology fit' between merger candidates. The findings of the patent analysis are compared with the business press commentary on the BP Amoco merger at the time of the announcement. The Chapter also describes the challenges and limitations of applying patent analysis to evaluate a merger that were identified during the course of the study.

7.2 Data Collection - Technology Fit

The technology fit evaluation utilised data collected earlier in the study. The number of patents granted and their technology area distribution (1993-1998) were collected from the USPTO website as described in Chapter Four. Citation analysis for IPC classes C07 and C08 were conducted for the period 1996-1998, as detailed in Chapter Five. In addition, the primary IPC subclass and number of citations were recorded for all BP and Amoco patents granted during 1996-1998. These data were tabulated to explore the technology focus areas and patent quality for both companies.

7.3 Results and Discussion - Technology Fit

The first stage of the 'technology fit' analysis involved a general overview of the companies' patent portfolios in terms of magnitude and technology areas. Table 7.1 summarises the total number of patents granted during the period 1993-1998 for some of the oil companies within the current study. Amoco received more patents

Table 7.1 Oil Companies - Number of US Patents Granted (1993-1998)

	Time Period		
Company	**1993-1998**	**1993-1995**	**1996-1998**
Amoco	483	287	196
BP	303	166	137
BP & Amoco	786	453	333
Exxon	1385	747	638
Shell	1001	610	391

than BP but both companies were granted substantially fewer patents than Shell and Exxon, the leading oil companies at that time (Rhodes and Crow, 1998). However, the combined BP Amoco patent portfolio gives the merged company a patent volume closer to that of Shell and Exxon.

Table 7.2 presents the distribution of patents across IPC technology areas over the time frame 1993-1998. BP's patents are heavily concentrated in IPC Section C (Chemistry; Metallurgy) and IPC Section B (Performing Operations; Transporting) whereas Amoco's patents are more broadly distributed across the technology areas. The combination of BP and Amoco's patent portfolios therefore resulted in an increased technological diversity from BP's point of view. This observation is reinforced when the number of different IPC classes occupied by the companies' patents is calculated (Table 7.3). The combined BP Amoco portfolio has a presence in nearly twice as many IPC classes as BP alone. This combined portfolio has a technology diversity profile very similar to those of Exxon and Shell.

The second stage of the patent analysis focused on the areas of polymer chemistry and organic chemistry (represented by IPC classes C08 and C07). Table 7.4 and Table 7.5 summarise the number of patents containing IPC classes C08 and C07 for some of the oil companies studied. BP has more patents in the polymer technology area (IPC class C08) than Amoco but the combined BP Amoco portfolio has less than half the number of polymer patents assigned to either Shell or Exxon. In the organic chemistry area (IPC class C07), Amoco has more patents than BP and the

Table 7.2 Oil Companies – Technology Area Distribution (1993-1998)

	IPC Section							
Company	**% A**	**% B**	**% C**	**% D**	**% E**	**% F**	**% G**	**% H**
Amoco	2.4	17.7	55.5	1.0	5.4	2.1	9.2	6.6
BP	-	21.6	72.5	0.9	0.6	0.9	3.2	0.3
BP & Amoco	1.5	19.2	61.8	1.0	3.6	1.6	7.0	4.3
Exxon	0.4	16.3	68.5	0.9	1.9	1.6	9.4	0.8
Shell	0.8	12.8	64.9	1.1	11.1	3.4	5.0	1.0

%Y = % Occurrence of IPC Section Y

A description of this calculation is provided in Appendix A2

The definitions of the IPC Sections are also listed in Appendix A2

Table 7.3 Oil Companies – Technology Diversity (1993-1998)

	Number of Different IPC Classes Listed (Grouped by Section)								
Company	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**Total**
Amoco	4	10	9	5	3	6	6	3	46
BP	-	9	10	3	1	1	3	1	28
BP & Amoco	4	14	11	5	3	6	6	3	52
Exxon	4	18	16	5	3	11	5	3	65
Mobil	6	20	10	1	3	8	5	2	55
Shell	3	13	13	4	3	12	8	3	59

combined BP Amoco portfolio is larger than those of Exxon and Shell.

Patent citation counts were examined to investigate the quality of patents within the polymer and organic chemistry areas. Table 7.6 summarises the citations received within IPC class C08 and Table 7.7 lists the corresponding data for IPC class C07. In both the C08 (polymer chemistry) and C07 (organic chemistry) categories, BP's patents are more highly cited than those of Amoco. If citation counts are a reliable indicator of patent quality, then the combined BP and Amoco portfolio shows a

Table 7.4 Oil Companies - Patents Containing IPC Class C08 (1996-1998)

	Grant Year			
Company	**1996-1998**	**1996**	**1997**	**1998**
Amoco	27	13	9	5
BP	40	10	17	13
BP & Amoco	67	23	26	18
Exxon	165	52	63	50
Shell	168	46	54	68

Table 7.5 Oil Companies - Patents Containing IPC Class C07 (1996-1998)

	Grant Year			
Company	**1996-1998**	**1996**	**1997**	**1998**
Amoco	63	20	18	25
BP	44	7	16	21
BP & Amoco	107	27	34	46
Exxon	92	25	28	39
Shell	67	23	16	28

weaker overall profile in the chemistry area than that of BP alone. The quality of the merged BP Amoco portfolio appears similar to that of Shell but weaker than Exxon's portfolio over the period studied.

The final stage of the 'technology fit' patent analysis investigated the technological diversity of BP and Amoco's most highly cited patents. In an attempt to focus on the companies' most significant patents, only patents receiving seven or more citations were tabulated (this exceeds the 'one citation per year' approximation for the 'average' US patent used in Chapter Five). Table 7.8 lists the primary (first listed) IPC subclass of BP and Amoco's most highly cited patents (1996-1998). The results

Table 7.6 Oil Companies – Citations Received (1996-98 Patents; IPC Class C08)

	Total No.	Number of Patents Receiving Citations		
Company	**Of Patents**	**<10 Citations**	**10-19 Citations**	**20+ Citations**
Amoco	27	26	1	-
BP	40	38	-	2
BP & Amoco	67	64	1	2
Exxon	165	150	10	5
Shell	168	161	7	-

Table 7.7 Oil Companies – Citations Received (1996-8 Patents; IPC Class C07)

	Total No.	Number of Patents Receiving Citations		
Company	**Of Patents**	**<10 Citations**	**10-19 Citations**	**20+ Citations**
Amoco	63	63	-	-
BP	44	42	2	-
BP & Amoco	107	105	2	-
Exxon	92	82	9	1
Shell	67	65	2	

presented in Table 7.8 suggest that BP and Amoco's technological strengths prior to their merger lay in complementary areas, with very little overlap. Whilst BP's strengths lay in catalysis (IPC subclass B01J) and chemistry (IPC Section C), Amoco's most highly cited patents related to drilling technology (IPC subclass E21B) and electricity (IPC Section E).

Taken in isolation, the patent analysis suggests that the primary outcome of the BP Amoco merger was the creation of a company with increased technological diversity. The citation analysis also indicates that the companies provided complementary technological strengths to the alliance. BP's highest quality patents were focused in the petrochemicals area whereas Amoco's related to exploration and production

Table 7.8 Technology Distribution of BP and Amoco Patents (1996-98)

	No. Patents Receiving 7+ Citations (Grouped By IPC Subclass)							
Company	**B01D**	**B01J**	**B32B**	**B65D**	**C01B**	**C07C**	**C08F**	**C08G**
Amoco	-	-	1	1	2	-	-	1
BP	2	5	1	-	-	3	1	-
Company	**C08L**	**C10M**	**C12M**	**C25B**	**D05B**	**E21B**	**F01N**	**G01N**
Amoco	2	-	1	-	1	4	1	-
BP	-	2	-	3	-	-	-	1
Company	**G02B**	**G06F**	**H01B**	**H01L**	**H01S**	**H04B**	***Total***	
Amoco	1	2	2	3	1	1	*24*	
BP	-	-	-	-	-	-	*18*	

The IPC subclass definitions are listed in Appendix A4

activities. These trends in the patent data should, however, be interpreted with caution because the short time frame studied may not be indicative of the companies' entire patent portfolios.

The findings of the patent analysis were then compared to the business press commentary on the BP Amoco merger to understand the extent to which 'technology fit' considerations influenced the merger. When the merger was announced BP's CEO, Sir John Browne, indicated that the ability to lead large-scale development projects was a key driver for the merger (Cavenagh, 1998). This was because the merger created a company with sufficient financial strength to be a credible bidder for access to new oil and gas reserves (The Economist, 1998). Table 7.9 indicates the merger created a third oil 'supermajor', with a similar market presence to Shell and Exxon.

The delivery of cost-savings that would be unachievable from internal restructuring (and so improving shareholder returns) was also identified as a major benefit of the merger (Stonham, 2000). A key driver of the merger was the complementary nature

Table 7.9 Oil Companies – Sales Figures (1996)

Company	Global Sales ($ million)	% Sales in US	Chemicals Sales ($ million)	% Sales in Chemicals
Amoco	32,150	78	5,698	18
BP	76,602	24	5,667	7
BP & Amoco	108,752	40	11,365	10
Exxon	116,728	21	11,430	8
Shell	128,313	23	14,035	11

1996 data (Hoover's 1998a, 1998b)

of BP and Amoco's assets. Amoco's natural gas business was significantly larger than that of BP, whereas BP owned considerable oil reserves (Rhodes and Crow, 1998). The press also noted that the companies had complementary chemical product portfolios (Milmo, 1998). However, the consensus amongst the industry analysts was that the BP Amoco merger was driven by the need to gain scale within upstream activities and they found "their petrochemicals sectors bolstered almost accidentally" (Robinson, 2000).

This brief analysis suggests that 'technology fit' considerations played only a minor role in the BP Amoco merger decision. The key factors underlying the merger decision – creating financial power to bid for large-scale projects and combining complementary oil and gas reserves – could not be identified by patent analysis alone.

7.4 Practical Considerations for Patent Analysis of Mergers

The research undertaken for the current study indicates that patent analysis can provide additional perspective in a merger analysis but there are limited situations where patent considerations will influence the final merger decision.

The BP Amoco analysis suggests that 'technology fit' is often of secondary importance to market-related factors, even if the merger involves technologyintensive companies. A similar situation emerged in the Reckitt Benckiser pilot study (Appendix A1). Patent portfolio analysis identified an extremely low level of patenting for Benckiser both in the US (Table A1.2) and in Europe (data not shown). Taken in isolation, this raises doubts about the suitability of Benckiser as a merger partner for Reckitt & Colman. However, the merger produced a leading company in the household cleaning sector (Table A1.3). Benckiser's strong management and the companies' complementary geographical penetration were identified as key factors influencing the merger decision (Willman, 1999). Benckiser's limited patent portfolio reflects the company's policy to focus on speed to market as the primary innovation strategy (Jane Warwick, Reckitt Benckiser, personal communication October 2002). Again, this highlights that a purely patent-based analysis may generate a distorted technology profile due to differences in company policy towards patenting.

However, in some cases, 'technology fit' may be a key driver of mergers. For example, a company may seek to consolidate strengths within a specific technology area or may seek a merger partner with complementary strengths in order to diversify. In such a scenario, patent searches and citation analysis may help to identify potential merger candidates and assess the quality of their technology. This approach formed the basis of a recent analysis of the Glaxo-Wellcome and SmithKline Beecham merger within the pharmaceuticals sector (Breitzman *et al*, 2002). The Breitzman study concluded that complementary technology strengths contributed to the merger decision, but the study made no assessment of the contribution of other factors that were not technology related.

As noted in Chapter Four, the transformation of patent information into product-based categories is not always straightforward. A further observation from the current study is that highly focused patent searches would be required to target a specific product area. The current study's IPC subclass searches provided insufficient detail to identify BP and Amoco's petrochemical products (Milmo, 1998). A combination of technology keyword and patent classification search terms would be required for such a targeted analysis.

One particular area of merger evaluation where patent analysis may add value is that of due diligence. At a first level, patent analysis can identify the extent of patent protection supporting key products and confirm that relevant patents have been maintained (Managing Intellectual Property, 1999). Patent analysis can also provide unique perspective in identifying key inventors within an organisation, to ensure their retention. Indeed, Ernst and Vitt, (2000) suggest that head-hunting key inventors may be a viable alternative to the complexities of a full company merger.

7.5 Chapter Seven Conclusions

The current investigation suggests that patent statistics may help build a picture of the merger environment but there are limited situations where patent information plays a key role in the merger analysis. The BP Amoco and Reckitt Benckiser case studies have highlighted that multiple factors influence mergers. Technological capability may be of minor importance to the merger decision, even in industries with significant R&D activity. Patent analysis can provide unique perspective on certain aspects of a merger, particularly at the due diligence phase. However, as a merger analysis tool, it appears to be of secondary importance to financial and product market information.

CHAPTER EIGHT
STUDY CONCLUSIONS

8.1 Recap of the Study Objectives

The current study has explored the value of patent analysis in an industrial context. An empirical patent analysis has formed the focus of the study, comparing the technology profiles of a group of competitor companies within the oil and petrochemicals area. A range of patent analysis techniques were tested and the practical considerations which may impact the usefulness of patent analysis within the corporate environment were identified.

The specific research questions this study has aimed to address are restated below:

- What are the benefits and limitations of a simple patent quantity analysis?
- What are the benefits and limitations of using International Patent Classification (IPC) data to measure technological diversity?
- Is there an association between patent citation counts and the commercial significance of a patent?
- What are the benefits and limitations of patent bibliographic analysis?
- To what extent do patent statistics add value in a merger analysis?

The remainder of this Chapter summarises the key findings of the study in relation to these research questions.

8.2 Patent Quantity Analysis

The primary advantage of patent quantity analysis is the speed with which the analysis can be conducted. The technique described in this study provides a rapid 'snapshot' of a company's patenting activity but a more advanced quantity analysis could explore the overall portfolio size and rate of change. A key limitation of patent quantity analysis is that it provides no indication of the quality of the patents or the extent to which they are commercially significant.

Several of the practical challenges encountered during the patent quantity analysis are also applicable to the more sophisticated techniques tested later in the study. Company name consolidation is a prerequisite for all forms of company-based patent analysis. This consolidation is necessary to identify the relevant patent sets and involves a significant research effort into company history. The example of BP and Standard Oil, Ohio in the current study illustrates how consolidation can impact the patent statistics. A further observation is that patent analysis may identify differences between companies but, taken in isolation, does not explain the reasons underlying these differences. Additional perspective on factors such as company patent policy or home-country patent laws are needed to develop a more complete interpretation of the patent statistics.

8.3 Patent Technology Area Analysis

The International Patent Classification (IPC) system provides a simple approach to group patents according to technology area. Searches can be conducted at different levels of the classification hierarchy or combined with keyword searches, depending on the level of detail required. A limitation of the USPTO database is that IPC searches alone cannot distinguish the primary IPC category from the more peripheral classifications. The IPC misclassification observed in Table 5.8 also highlights that administrative errors can occur and this may impact the robustness of the patent statistics. A further concern for a business-focused patent analysis is how to correlate IPC categories with industry or product areas. One reason why difficulties can arise is that patents may be drafted broadly but only commercialised within a very specific product area.

8.4 Patent Citation Analysis

The experiment which compared citation counts with expert grading suggests that there is a positive association between patent citation counts and the commercial significance of that patent. This supports the use of citation data to measure and compare the quality of companies' patent portfolios.

Patent citation data is readily accessible for US patents via the USPTO website. However, the generation of equivalent patent reference lists is not mandatory in other geographies, making international comparisons difficult. This limitation also applies to the patent bibliographic information discussed in Section 8.5.

A small-scale investigation, such as the current study, allows a comparison of general trends within the companies studied but is insufficient to measure differences between technology areas or between industries. This type of full scale statistical analysis would require some form of automated data retrieval because manual collection takes approximately one minute per patent.

One factor which may limit the usefulness of the citation technique for competitor analysis is the time lag for patents to become highly cited. Direct indicators of a new technology's impact, such as market share information, may be available before its importance is reflected in the patent citation statistics. It would be interesting to explore the time taken for patents to become highly cited in a follow-up study. The results of such a study would indicate whether citation analysis has any value as an early warning indicator or whether its benefits are solely as a retrospective analysis tool.

8.5 Patent Bibliographic Analysis

The findings of the current study raise several concerns regarding the usefulness of patent analysis techniques based on bibliographic information. Automated data collection would be essential to conduct citation linkage, technology cycle time or science linkage analyses of even a modest size. The citation linkage technique may have some value as an indicator of technological leadership but the value of technology cycle time and science linkage as indicators of 'technology quality' is less clear.

Two methodology-related issues were identified during the course of the bibliographic analyses. The definition of what constitutes a 'science reference' introduces an element of subjectivity into the science linkage analysis. Of greater concern, the data collected in the current study suggest there may be significant inter-company differences in the volume of the 'References Cited' list. Additional research into this observation is recommended because, if this trend is confirmed, it could introduce distortions into patent comparisons between companies, including citation-based analyses.

8.6 Patent Analysis of Mergers

The greatest value of patent analysis within a merger appears to be at the due diligence phase, to ensure that key intellectual assets are identified and accounted for in the transaction. The two case studies in the current investigation highlight that multiple factors can influence the merger decision and patent analysis is often of secondary importance to financial and product market information. Patent analysis appears most relevant for mergers in sectors such as pharmaceuticals, where technology performance is the key differentiator of companies.

8.7 Patent Analysis in Industry – Final Considerations

The decision to undertake a patent analysis is influenced by several factors, including the resources required to conduct the study, the relevance of the output and the availability of the information from other sources.

The current study has confirmed the feasibility of conducting a patent analysis using data gathered from free-to-access patent databases. However, for a study of any magnitude, some form of automated data retrieval would be required. Patent quantity and technology area analyses have the benefit of speed but provide no indication of patent quality. Citation analysis adds a degree of complexity to the research but appears to be a valid indicator of the patents' significance. The value of the bibliographic-based methods appears to be more marginal. In a merger evaluation, patent analysis would be most effective at the due diligence phase or if the merger were technology-driven.

The inherent time lag of patent statistics has been mentioned only briefly in this study but may have a significant impact on the value of patent analysis for competitor evaluation. Quantitative patent techniques appear best suited for a retrospective performance analysis. An early warning of new technologies may be best achieved by more qualitative approaches, such as monitoring publications of new patent applications.

There is a temptation to assume that patent analysis is infallible, possibly because the output is numerical. However, the current research has identified numerous factors that may distort the patent statistics, ranging from company name consolidation to individual companies' policies on patenting.

The study has also highlighted that patent statistics are most informative when they form part of a broader competitive analysis. Patent analysis in isolation may identify differences between companies but additional perspective, such as product portfolio or market share information, will aid the interpretation of the patent data. Conversely, patent statistics may provide unique perspective, such as the identification of key inventors, to complement information gathered from other sources.

The overall conclusion of the study, therefore, is to echo the sentiment of Jacob Schmookler which introduced this dissertation. Patent analysis has a valid place in the corporate environment, provided the output is interpreted judiciously.

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APPENDIX A1
PATENT ANALYSIS PILOT STUDY

The primary objective of the pilot study was to investigate the feasibility of conducting a patent analysis using free-to-access patent databases. The pilot study focused on the patent portfolios of Benckiser and Reckitt & Colman, who merged to form Reckitt Benckiser (completed December 1999). Reckitt Benckiser's major competitors in the US household cleaning category were identified from market share information (Euromonitor) and included in the patent analysis. Table A1.1 summarises the number of US patents granted to each company in the decade preceding the Reckitt Benckiser merger (data collected from USPTO website).

Table A1.1 Household Cleaning Company Patents (1990-1999)

Company	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Benckiser	1	1	2	2	-	-	-	-	-	-
Clorox	22	19	23	19	14	14	14	9	27	25
Colgate-Palmolive	60	68	53	52	52	65	70	66	110	138
Procter & Gamble	123	138	151	151	202	216	333	393	438	526
Reckitt & Colman	3	4	2	1	1	10	7	11	13	18
SC Johnson	23	16	18	9	8	9	13	22	33	55
Unilever	87	95	81	73	95	96	73	69	84	81

Note: Unilever figures include data for both Unilever and Lever Brothers

The pilot study also investigated the use of IPC classifications as a search tool to focus on specific technology areas. Table A1.2 summarises the results of a search in the 'detergent' technology area, as classified by IPC subclass C11D (defined as, "detergent compositions; use of single substances as detergents; soap or soap-making; resin soaps; recovery of glycerol").

Table A1.2 Household Cleaning Company 'Detergent' Patents (1990-99)

Company	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Benckiser	1	1	1	1	-	-	-	-	-	-
Clorox	7	6	9	7	8	7	5	5	18	11
Colgate-Palmolive	22	28	19	21	13	34	39	32	53	82
Procter & Gamble	27	23	20	33	36	56	81	98	120	132
Reckitt & Colman	-	1	-	-	-	5	2	6	7	10
SC Johnson	-	2	-	2	3	-	2	4	8	13
Unilever	29	42	29	27	39	36	32	31	51	42

Note: Unilever figures include data for both Unilever and Lever Brothers

The pilot study identified that Benckiser and Reckitt & Colman were granted very few patents in the period preceding their merger – too few to progress to a detailed patent 'quality' analysis. The reason underlying this low patent count is discussed in Chapter Seven. However, despite its limited patent portfolio, Reckitt Benckiser has established itself as a key player in the US household cleaning category (Table A1.3).

Table A1.3 US Household Cleaning Products Company Shares (2000)

Company	US % Retail Value
Procter & Gamble	32.4
SC Johnson	10.4
Clorox	9.4
Unilever	8.5
Reckitt Benckiser	7.6
Colgate-Palmolive	4.4

Data from Euromonitor US Household Cleaning Report (published 2002)

APPENDIX A2

TECHNOLOGY AREA ANALYSIS – ADDITIONAL DATA

Table A2.1 Technology Area Distribution During Period 1993-1995

	IPC Section							
Company	**% A**	**% B**	**% C**	**% D**	**% E**	**% F**	**% G**	**% H**
Amoco	1.2	21.1	52.1	1.5	5.4	1.5	10.1	7.1
BASF	11.4	12.9	66.0	4.6	0.1	0.4	4.1	0.7
BP	-	18.6	75.5	1.1	-	1.6	2.7	0.5
Dow Chemical	4.1	22.7	61.7	3.0	0.5	1.6	5.6	0.8
Exxon	0.3	19.3	68.8	1.0	2.6	1.3	6.3	0.5
Mobil	1.7	23.2	60.0	0.1	10.1	1.6	2.9	0.4
Montell	-	15.4	84.6	-	-	-	-	-
Shell	-	10.6	65.1	1.0	13.7	3.9	4.6	1.0
Targor	-	-	-	-	-	-	-	-
Union Carbide	2.7	25.2	67.6	1.8	-	0.5	0.9	1.4
All Patents	*15.0*	*21.0*	*15.3*	*1.4*	*2.8*	*8.7*	*19.6*	*16.2*

%Y = % Occurrence of IPC Section Y

$$= \frac{\text{Total Number of Occurrences of Section Y}}{\text{Total Number of Occurrences of All Sections}} \times 100\%$$

Note that data were collected on an IPC class basis and then aggregated to generate IPC section data. This may introduce some distortions into the reported data. For example, a patent which lists two different IPC classes within the same IPC section will be counted twice e.g. one patent which includes IPC classes C07 and C08 in its IPC listing will contribute two occurrences to IPC Section C.

Table A2.2 Technology Area Distribution During Period 1996-1998

	IPC Section							
Company	**% A**	**% B**	**% C**	**% D**	**% E**	**% F**	**% G**	**% H**
Amoco	4.2	13.0	60.3	0.4	5.4	2.9	7.9	5.9
BASF	11.2	14.5	64.2	5.5	0.2	1.1	2.9	0.4
BP	-	25.3	68.8	0.6	1.3	-	3.9	-
Dow Chemical	6.2	23.4	57.5	1.6	0.9	1.2	6.7	2.5
Exxon	0.5	13.7	68.3	0.8	1.4	1.9	12.3	1.1
Mobil	0.8	26.5	59.7	-	6.2	2.6	4.2	-
Montell	-	27.4	58.9	9.5	0.0	2.1	2.1	-
Shell	2.0	16.1	64.6	1.1	7.0	2.7	5.4	0.9
Targor	-	10.5	89.5	-	-	-	-	-
Union Carbide	2.8	16.6	73.1	2.1	-	-	2.8	2.8
All Patents	*16.2*	*18.5*	*14.6*	*1.3*	*2.5*	*7.7*	*21.9*	*17.3*

%Y = % Occurrence of IPC Section Y

IPC Sections

Section A Human Necessities
Section B Performing Operations; Transporting
Section C Chemistry; Metallurgy
Section D Textiles; Paper
Section E Fixed Constructions
Section F Mechanical Engineering; Lighting; Heating; Weapons; Blasting
Section G Physics
Section H Electricity

APPENDIX A3

PATENT CITATION ANALYSIS – ADDITIONAL DATA

Table A3.1 Breakdown of Number of Citations Received (1996-98; Class C08)

Company	Total No. Patents	Number of Patents Receiving Citations (Grouped by Citation Counts)								
		0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40+
Amoco	27	19	7	1	-	-	-	-	-	-
BASF	463	385	60	13	2	1	-	2	-	-
BP	40	36	2	-	-	1	-	1	-	-
Dow Chemical	214	142	49	11	5	4	1	-	1	1
Exxon	165	117	33	6	4	2	2	-	1	-
Mobil	34	9	17	5	3	-	-	-	-	-
Montell	51	29	16	4	2	-	-	-	-	-
Shell	168	142	19	4	3	-	-	-	-	-
Targor	9	5	1	-	-	2	-	1	-	-
Union Carbide	66	47	13	4	1	-	1	-	-	-

Table A3.2 Breakdown of Number of Citations Received (1996-98; Class C07)

Company	Total No. Patents	Number of Patents Receiving Citations (Grouped by Citation Counts)				
		0-4	5-9	10-14	15-19	20-24
Amoco	63	58	5	-	-	-
BASF	444	397	36	9	2	-
BP	44	39	3	1	1	-
Dow Chemical	98	83	10	3	2	-
Exxon	92	72	10	4	5	1
Mobil	86	71	10	4	1	-
Montell	4	3	-	-	1	-
Shell	67	55	10	2	-	-
Targor	8	7	1	-	-	-
Union Carbide	32	29	2	1	-	-

APPENDIX A4
IPC SUBCLASS DEFINITIONS

Definitions of IPC subclasses listed in Table 7.8
(definitions obtained from : http://www.wipo.org)

B01D	Separation
B01J	Chemical or physical processes, e.g. catalysis, colloid chemistry; their relevant apparatus
B32B	Layered products, i.e. products built up of strata of flat or non-flat, e.g. cellular or honeycomb, form
B65D	Containers for storage or transport of articles or materials, e.g. bags, barrels, bottles, boxes, cans, cartons, crates drums, jars, tanks, hoppers, forwarding containers; accessories, closures, or fittings therefore; packaging elements; packages
C01B	Non-metallic elements; compounds thereof
C07C	Acyclic or carbocyclic compounds
C08F	Macromolecular compounds obtained by reactions only involving carbon-to-carbon unsaturated bonds
C08G	Macromolecular compounds obtained otherwise than by reactions only involving carbon-to-carbon unsaturated bonds
C08L	Compositions of macromolecular compounds
C10M	Lubricating compositions; use of chemical substances either alone or as lubricating ingredients in a lubricating composition
C12M	Apparatus for enzymology or microbiology
C25B	Electolytic or electrophoretic processes for the production of compounds or non-metals; apparatus therefor
D05B	Sewing
E21B	Earth or rock drilling; obtaining oil, gas, water, soluble or meltable materials or a slurry of minerals from wells
F01N	Gas-flow silencers or exhaust apparatus for machines or engines in general; gas-flow silencers or exhaust apparatus for internal-combustion engines

G01N	Investigating or analysing materials by determining their chemical or physical properties
G02B	Optical elements, systems or apparatus
G06F	Electric digital data processing
H01B	Cables; conductors; insulators; selection of materials for their conductive, insulating or dielectric properties
H01L	Semiconductor devices; electric solid state devices not otherwise provided for
H01S	Devices using stimulated emission
H04B	Transmission