Technological Powerhouse or Diluted Competence: Techniques for Assessing Mergers via Patent Analysis

by

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Abstract

On a daily basis, we are bombarded with the news of yet another mega-merger. The business press generally greets these announcements with breathless projections based on extrapolations of combined sales, earnings, and R&D spending, with little emphasis on whether the merged companies will be worth the sum of their parts. In this paper we examine patent analysis techniques for evaluating the technological strength of merger candidates, and explore the notion that the technological quality of the merged company may be diluted rather than enhanced. We will also use patent analysis methods for examining the market value of companies, to determine whether a merger target is over or under priced. We will explore all of these techniques within the context of a case study of the proposed merger between Glaxo-Wellcome and SmithKline Beecham, although the techniques can be readily applied to any merger within an R&D intensive industry.

I. Introduction

Any merger between large technology-based companies raises two important issues – does the merger make sense in technological terms, and are the financial terms of the merger appropriate. Both of these issues are based in part upon the quality of the technology owned by each company involved in the merger, which in turn is reflected in the patents owned by the companies. Using the example of the proposed merger between Glaxo-Wellcome and SmithKline Beecham, this paper will show how analysis of patent portfolios can be used to provide insights into the technological fit and relative valuations of merger candidates.

Combining Glaxo-Wellcome and SmithKline Beecham will create a company with some $25 billion in annual sales, an R&D budget of $4 billion, and a market capitalization of $177 billion (Sorkin and Peterson, 2000). The merger has been reported in newspapers and business magazines across Europe and America, along with comments referring to the combined company as a technological powerhouse, with R&D spending nearly double that of rivals Merck and Pfizer, and sales equal to or exceeding the industry giants.

One flaw in such an analysis is that companies leverage R&D dollars in different ways. The real issue is whether the combined company will use its R&D expenditure as efficiently as Merck, Pfizer and other competitors. In particular, the question must be addressed of whether doubling R&D spending leads to twice the number of patents/products of the same or better quality.

A second flaw is that the products on which the future sales of the combined company are projected are already starting to lose their patent protection. When a drug loses its patent protection, it is estimated that its sales drop 50-85% in the following year (Kindel, 2000). SmithKline has thirteen drugs that have gained FDA approval and still have some patent protection (Electronic Orange Book, 2000), including its blockbuster anti-anxiety drug Paxil which reached $2 billion in worldwide sales in 1999 (SmithKline Beecham Annual Report 1999). Many will lose patent exclusivity in the next few years, and all will lose at least some patent protection by 2008[1] according to the Orange Book. We should point out that SmithKline is not alone - a similar analysis of almost any pharmaceutical company would show a number of drugs losing patent protection in the near future.

In order for pharmaceutical companies to maintain or increase their sales in the future, they must innovate to ensure that they have new drugs in the pipeline to replace those that are to lose their patent protection. Products going off patent are not the only reason for companies to innovate. In the pharmaceutical (or any other) industry, if a competitor creates a more effective product, the sales of an existing product may fall. The future value of companies therefore lies in their ability to continue innovating. One way of measuring this ability to innovate is through analysis of the quality of the patents that companies produce. This paper will provide such an analysis of Glaxo-Wellcome and SmithKline Beecham, and examine how their proposed merger may affect the quality of the patents they produce.

[1] Most drugs are protected by more than one patent. There may be patents covering the chemical entity, for use at different dosages, for different delivery methods etc.

II. Basics of Patent Citation Analysis

The idea of a patent is simple. An inventor or his/her company is granted a twenty-year monopoly on an invention, in return for detailed disclosure of how the invention works. Rather than stifle innovation, the idea is to spur innovation by the following win-win scenario. The inventor gets twenty years of exclusive control of his/her invention, while the public gets to see how the current invention works, and can therefore build and improve upon the innovation without the pitfalls of starting from scratch.

Patents are becoming increasingly important to commercial organizations. In 1999, 169,154 US patents were issued, twice the number issued a decade ago. Moreover, patents are not only important in old economy industries, such as chemicals and automotive manufacturing. Some of America's largest technology firms, including IBM, Texas Instruments, and Lucent, have become very aggressive about making money directly from their patented technologies. IBM alone had in excess of $1 billion in licensing revenue in 1999 from its stable of patents (Wysocki, 2000).

Given the growth of the patent system and the importance of managing intellectual property, it has become increasingly important to be able to analyze patent portfolios without sifting through thousands of individual patent documents. For this reason, patent citation analysis techniques have been developed to statistically analyze the quality and strength of patent portfolios.

Patent citation analysis is based on the citations that appear on the front page of patents. When an inventor applies for a patent s/he must show that the invention is novel, useful, and non-obvious to someone with average expertise in the same industry. To do so, the inventor will cite to earlier patents, and explain why the new patent improves on the earlier inventions. The patent examiner may also add earlier inventions that limit the scope of the new invention. It is fraud on the patent office not to cite earlier relevant work, and it is also undesirable to unnecessarily cite irrelevant work.

Given that almost all patents cite to earlier patents, one can easily count up the citations a patent receives from later patents. For example, the IBM patent in Figure 1 cites 10 earlier US patents. The first of these patents (US Patent # 3,995,215) is cited not only by the IBM patent, but also by 17 other patents. The idea of patent citation analysis is that when a patent receives many later citations, it is not a statistical accident, but due to a key idea involved in the cited patent, upon which others are building.

This does not mean that every important patent is highly cited, or that every highly cited patent is important. However, numerous validation studies have shown the existence of a strong positive relationship between citations and technological importance. For example, Carpenter et. al. (1981) found that patents related to IR 100 invention awards are cited twice as often as typical patents. Also, Albert et. al. (1991) showed that patents identified as important by industry experts were highly cited. Other studies have revealed a positive relationship between patent indicators and stock market valuations (Deng, Lev and Narin 1999) and between highly cited patents and increased sales and profits in the pharmaceutical industry (Narin, Noma and Perry, 1987)

There are three patent citation indicators that we derive from the front page of US patents.

Patent Impact – measured using Current Impact Index

The technological impact of a patent is measured based upon the number of times later patents cite to it. Hence, a company with many highly cited patents is assumed to be developing technology with a strong impact on later technological developments. However, using simple citation counts to measure patent impact is not sufficient, since older patents will have more time to accumulate citations. Also, the number of citations received by patents varies across industries. For these reasons, we use a normalized citation indicator - the *Current Impact Index* (CII) – to measure patent impact.

The CII is a measure of how often the last five years of a company's patents are cited by patents issued in current year, relative to all US patents. A CII of 1.0 shows that the last five years of a company's patents are cited as often as expected, compared to all US patents. A CII of 1.1 indicates 10 percent more citations per patent than expected, and so forth. Note that CII is a synchronous indicator, and moves with the current

year, looking back five years. As a result, when a company's patents from recent years start to drop in impact, this is picked up quickly as a decline in the current year's CII.

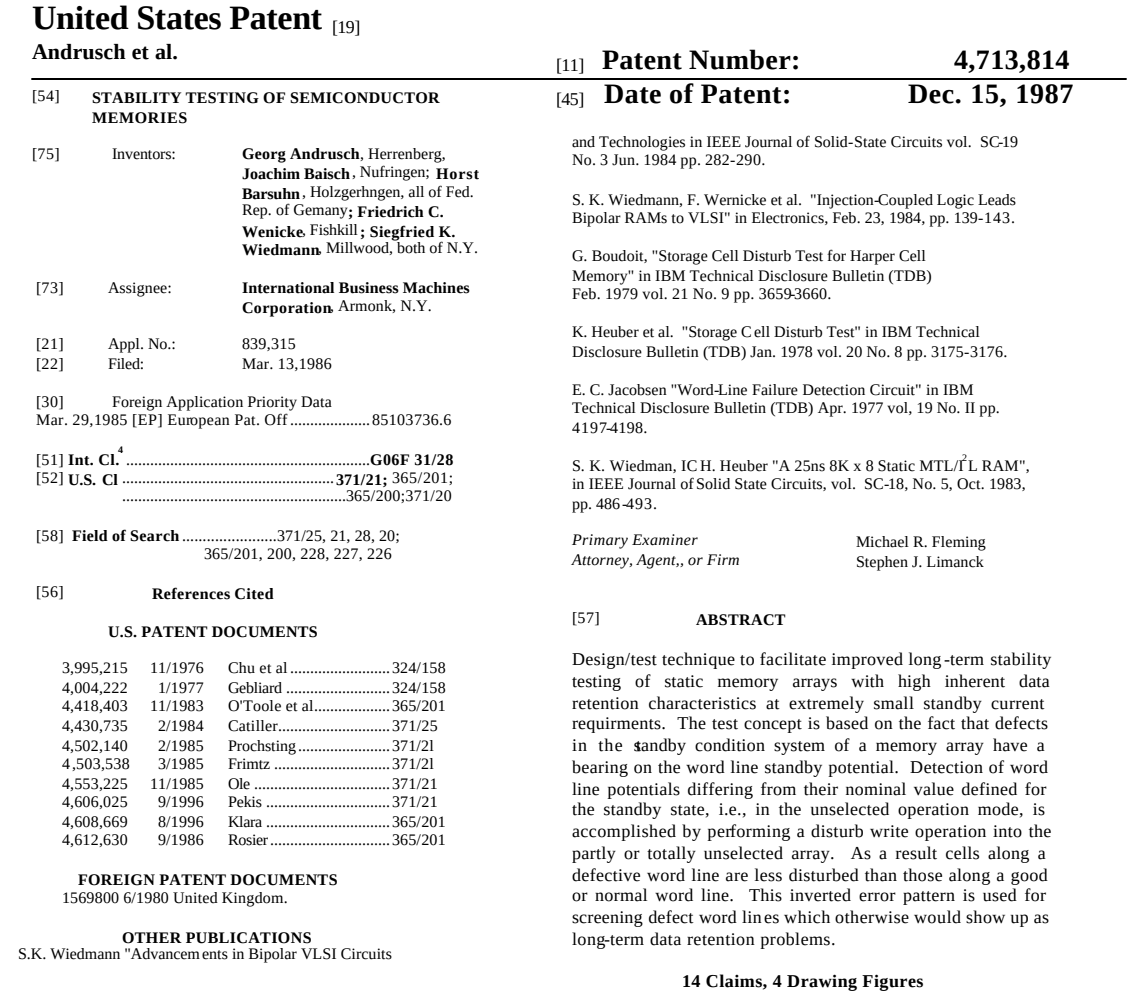
Speed of Innovation – measured using Technology Cycle Time

More can be done with citations than simply counting them. Calculating the median age of the cited patents provides insights into the age of the technology upon which a patent is building. By extending this calculation to a group of patents we derive the *Technology Cycle Time* (TCT). One can compute the TCT for a company's patent portfolio, to gain insights into how fast the company is innovating. A short TCT (relative to the rest of its industry) shows that a company's patents are citing recent technology, suggesting that the company is innovating quickly.

Links to Scientific Research – measured using Science Linkage

The IBM patent in Figure 1 cites 6 non-patent articles. These are listed in the "Other Publications" section of the front page. The citations in this section can be to any non-patent material such as brochures, books etc. Counting the subset of references that are specifically to scientific articles reveals how closely linked a patent is to cutting edge scientific research. A company's *Science Linkage (SL)* is defined as the average number of science references on the front pages of its patents. A high Science Linkage (relative to the industry norm), shows that a company is using scientific research extensively. This is particularly important in the pharmaceutical and biotechnology industries, since many important findings in these industries are reported in scientific journals.

Figure 1: Example Front Page from A U.S. Patent



United States Patent [19]
Andrusch et al.

[11] **Patent Number: 4,713,814**
[45] **Date of Patent: Dec. 15, 1987**

[54] **STABILITY TESTING OF SEMICONDUCTOR MEMORIES**

[75] Inventors: **Georg Andrusch**, Herrenberg, **Joachim Baisch**, Nufringen; **Horst Barsuhn**, Holzgerhngen, all of Fed. Rep. of Gemany; **Friedrich C. Wenicke**, Fishkill; **Siegfried K. Wiedmann**, Millwood, both of N.Y.

[73] Assignee: **International Business Machines Corporation**, Armonk, N.Y.

[21] Appl. No.: 839,315
[22] Filed: Mar. 13,1986

[30] Foreign Application Priority Data
Mar. 29,1985 [EP] European Pat. Off 85103736.6

[51] **Int. Cl.**[4] **G06F 31/28**
[52] **U.S. Cl** ..... **371/21;** 365/201; 365/200;371/20

[58] **Field of Search** 371/25, 21, 28, 20; 365/201, 200, 228, 227, 226

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4,606,025	9/1996	Pekis	371/21
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Primary Examiner Michael R. Fleming
Attorney, Agent,, or Firm Stephen J. Limanck

[57] **ABSTRACT**

Design/test technique to facilitate improved long-term stability testing of static memory arrays with high inherent data retention characteristics at extremely small standby current requirments. The test concept is based on the fact that defects in the standby condition system of a memory array have a bearing on the word line standby potential. Detection of word line potentials differing from their nominal value defined for the standby state, i.e., in the unselected operation mode, is accomplished by performing a disturb write operation into the partly or totally unselected array. As a result cells along a defective word line are less disturbed than those along a good or normal word line. This inverted error pattern is used for screening defect word lines which otherwise would show up as long-term data retention problems.

14 Claims, 4 Drawing Figures

Other Indicators

There are a number of other indicators that can be derived for use in patent analysis, including counting the number of patents over time, counting the number of foreign equivalents a patent has, tabulating the use of various keywords mentioned, identifying renewal rates etc. However, we believe the three indicators described above, plus simple patent counts, are sufficient to provide an understanding of how patent citation techniques can be employed to evaluate the technological effects of a merger.

III. Data

The patent data used in this study were taken from CHI Research's internal patent databases. These are complete US and EP patent databases with several value-added enhancements that make the analysis of innovation, R&D management, and economic policy possible.

One enhancement is a corporate thesaurus that carefully pieces together the corporate structure for major patenting entities, in order to produce accurate patent lists for companies, including all of their subsidiaries. This unification of the companies' various components is not a trivial process. After the standard clean-up of patent assignee names there are still some 12,900 different components of the top 1,400 companies, all of which are correctly assigned in the CHI database. Moreover the thesaurus is continually updated to reflect new mergers, acquisitions, divestitures, etc. to ensure that the corporate structures and any analyses remain accurate over time.

A second enhancement is that every patent is placed into one of 30 technology categories, based on a concordance between patent classes and international SICs. Also, each company is assigned to one of 26 industry groups. Patent data can therefore be completely normalized to account for differences in patenting across technology areas, and across industry groups. As a result, the quality of a company's patents can be compared to other companies within the same industry, and with the average for the industry as a whole. It also becomes easier to compare companies in different industries in terms of the quality of their patents, since industry effects are reduced by the normalization of the patent data.

IV. Assessing the Technological Fit between Merger Candidates

We employed three levels of analysis to assess the patented technology owned by Glaxo-Wellcome (referred to hereafter as Glaxo) and SmithKline Beecham (referred to hereafter as SmithKline). These levels are defined as views of the companies from different distances. Each level provides an increasing degree of detail regarding the companies' patenting activity. The purpose of this analysis is to highlight the extent to which Glaxo and SmithKline complement each other in technological terms.

In order to assess the technological quality and technological fit between Glaxo and SmithKline, it is useful to compare the two companies with several of their peers. In order to build a comparison set, we chose the top 6 other pharmaceutical companies in terms of 1997 sales (which were the latest available figures at the time). The comparison set with updated 1998 sales figures are: Merck ($26.9 billion) , Johnson & Johnson ($23.7 billion), Novartis ($23.2 billion), Bristol-Myers Squibb ($18.3 billion), American Home Products ($13.5 billion), SmithKline ($13.4 billion), Glaxo ($13.2 billion) and Pfizer ($12.7 billion) (Moody's International, 2000). Combining Glaxo and SmithKline will produce a company whose combined sales of $26 billion are similar to those of Merck, the largest of the pharmaceutical companies.

View from 100,000 Feet

This section provides the broadest view of companies, in that it examines overall trends in companies' patenting in the US. Later sections divide patents into specific categories. Table 1 reveals that that the R&D spending of the combined GlaxoSmithKline would far exceed that of Merck and the other companies in the industry. Table 1 also shows the relationship between patents and R&D expenditure. To examine this relationship, we counted the US and EPO (European Patent Office) patent documents in the years 1997-99 and assumed that these were developed with R&D dollars from 1995-97. Admittedly this is a rather crude estimate, given that R&D dollars are spent on other things besides patentable inventions, such as clinical trials. However, it is enlightening in that it shows the number of patents per $10 million R&D dollars varies

widely among the companies. Interestingly, SmithKline has produced the most patents in the last 3 years per R&D dollar, and Glaxo the least. The combined company will have twice the R&D spending of Merck, but Merck currently spends only two-thirds as much per patent, so the amount of innovation from the combined company is likely to be less than twice that of Merck.

Table 1: Patents versus R&D Spending

Company	Average Yearly R&D Spending 1995-97 ($10 Millions)	Average Yearly US & EP Patent Documents Published 1997-99	Patents Per $10 Million R&D
SmithKline Beecham	124	479	3.9
J & J	189	711	3.8
Merck & Co.	150	445	3.0
Amer. Home Prod.	145	336	2.3
Novartis	221	447	2.0
GlaxoSmithKline	334	627	1.9
Bristol-Myers Squibb	129	238	1.8
Pfizer	169	232	1.4
Glaxo Wellcome	210	148	0.7

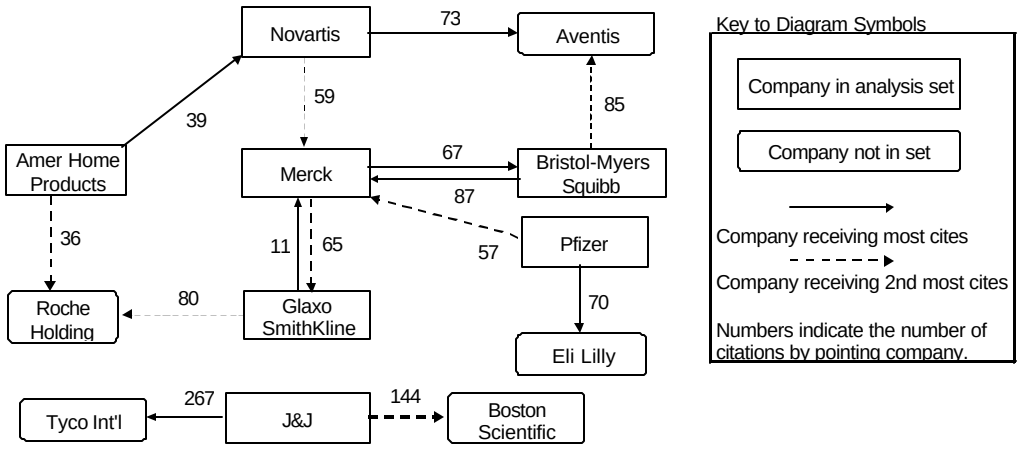
Table 2 contains the basic patent indicators for each of the companies for two 3-year time periods. These indicators show that the combined GlaxoSmithKline would be among the most prolific patenters, with its number of patents increasing over time. This increase is largely due to the huge growth in SmithKline's patenting in the last 3 years. However, the other indicators give us an indication of diluted competence. The combined GlaxoSmithKline patent portfolio is rather weak in terms of Patent Quality as measured by Current Impact Index, indicating that the impact of patents produced by the combined companies may be lower than that of Merck and others. The combined companies are also slightly slower than average in terms of innovation speed, and less science linked than most of the companies. These relatively poor indicators are largely the result of the weakness of SmithKline in each of the indicators (although it is improving in all but innovation speed). The net result is a combined company with more patents than Merck, but fewer quality patents than Merck. This is an important finding because, while the sales of the two companies are likely to be similar for a few years, sales growth, especially in the pharmaceutical industry, depends on continually renewing the pipeline of new drugs.

Table 2: US Patent Indicators

		#US Patents		Patent Quality		Innovation Speed		Science Linkage	
	Company	1994-96	1997-99	1994-96	1997-99	1994-96	1997-99	1994-96	1997-99
1	GlaxoSmithKline	728	997	0.6	0.7	8.6	8.6	5.8	7.0
2	Glaxo Wellcome	191	269	0.5	1.0	8.5	8.5	8.3	10.4
3	SmithKline Beecham	126	537	0.5	0.6	7.7	8.7	1.7	4.8
4	Merck & Co Inc	564	723	0.9	0.8	6.5	6.3	5.7	7.0
5	Pfizer Inc	259	348	0.9	0.7	9.3	8.5	3.3	3.4
6	Bristol-Myers Squibb	445	507	0.8	0.8	7.6	9.1	5.5	11.2
7	Novartis AG	1092	815	0.6	0.6	9.8	9.4	2.5	9.1
8	Amer Home Prod	663	681	1.1	0.6	7.3	8.3	5.9	8.0
9	J & J	796	1287	2.3	1.7	8.0	8.8	1.0	1.2

It is also possible to drill down further into the citation indicators to get an idea of who is building upon whom. Figure 2 is a linkage map showing companies that are technological leaders from a peer perspective. This map is built by drawing arrows from each of the eight starting companies to the companies that their 1999 US and EP patents cited to most and second most frequently. The technological leaders will thus have many arrows pointing to them. Although the quality of the GlaxoSmithKline patents has improved in the last 3 years, most companies are still building upon Merck's technology rather than GlaxoSmithKline's.

Figure 2: Citation Linkages From 1999 Patents to Earlier Patents of Peers



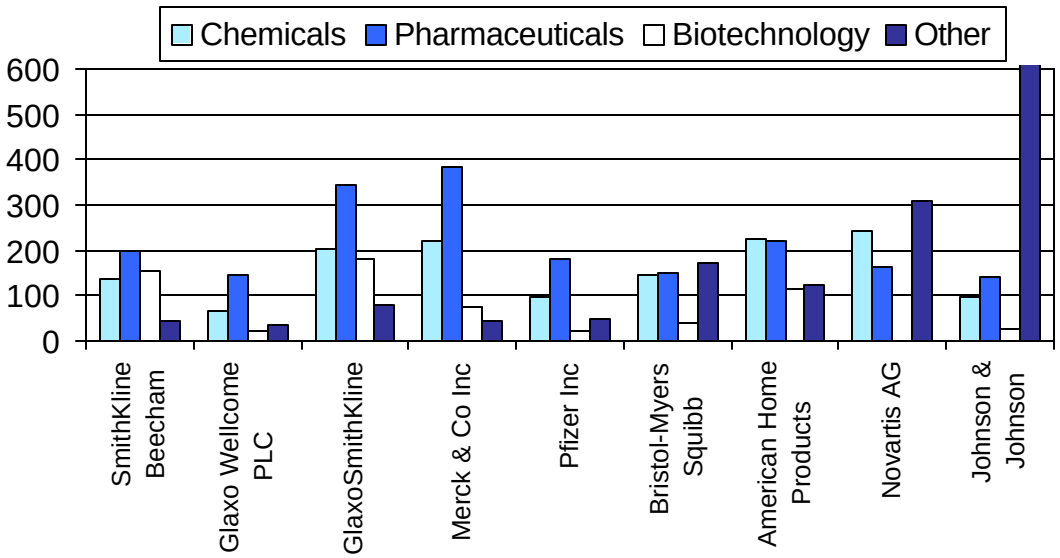
This first level of analysis offers little support to the idea that the GlaxoSmithKline merger will produce a technological powerhouse. Overall, the quality of Merck's patents continues to exceed that of the merged company. In addition, it is Merck that appears to be developing the technology upon which other companies are building.

View from 10,000 Feet

The overview above provides some useful insights into companies' patenting. However, it may be misleading to examine an overall patent set without paying attention to technological categories. In this section we will partially rectify that by dividing the patents into four large categories, Chemicals, Pharmaceuticals, Biotechnology, and Other. These categories are based on CHI's broad technology categories.

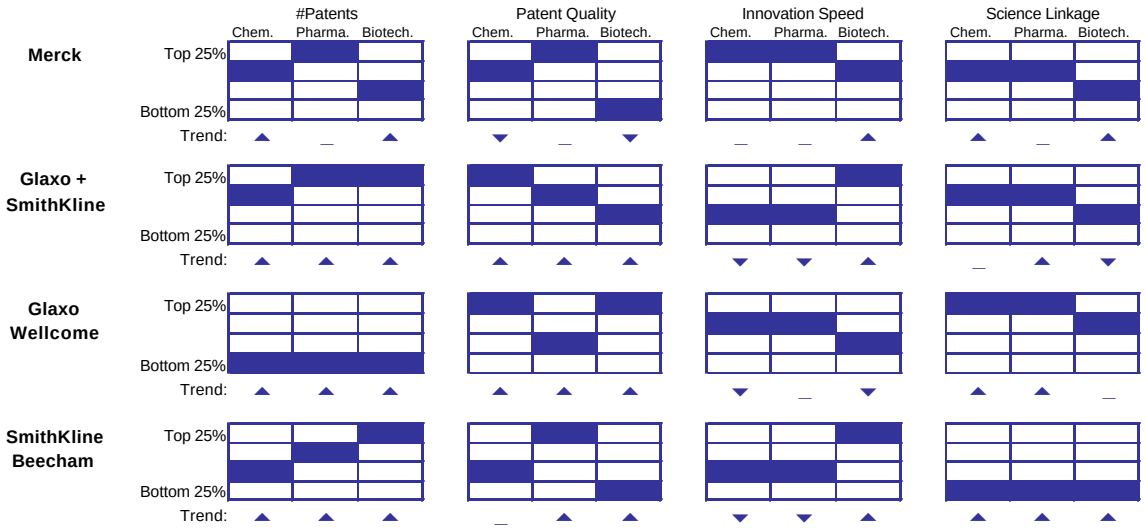
Figure 3 shows the number of patents for the eight selected companies in the four broad technology areas. This figure shows that J&J is not a typical pharmaceutical company. The vast majority of its patents are in 'other' (actually Medical Equipment), while most of the other companies have the majority of their patents in chemicals or pharmaceuticals. The combined Glaxo and SmithKline is again similar to Merck, with a similar proportion of patents in chemicals, pharmaceuticals, and other. The biggest difference is the combined company's significant lead in biotechnology patenting.

Figure 3



To study the effect of the merger in terms of patent impact, science linkage and innovation speed, we ranked the eight pharmaceutical companies into quartiles on each of these three indicators. Figure 4 shows the position of Glaxo, SmithKline and the combined company in Chemicals, Pharmaceuticals and Biotechnology (in order to simplify the presentation, all other companies except Merck are removed). This figure reveals that the combined company will be among the leaders in terms of number of patents across all three industries. There is also an interesting result regarding Patent Impact. Glaxo's Biotechnology and Chemicals patents have a higher impact than those of SmithKline, while the opposite is the case in Pharmaceuticals. This suggests that the two companies bring different strengths to the merger, and may therefore represent a good technological fit. The merger appears less positive with regard to Science Linkage. Glaxo is much more closely linked to scientific research than SmithKline in all three technologies, and the merger may dilute this link.

Figure 4 - Patent Indicators into Quartiles (US Patents 1995-99)



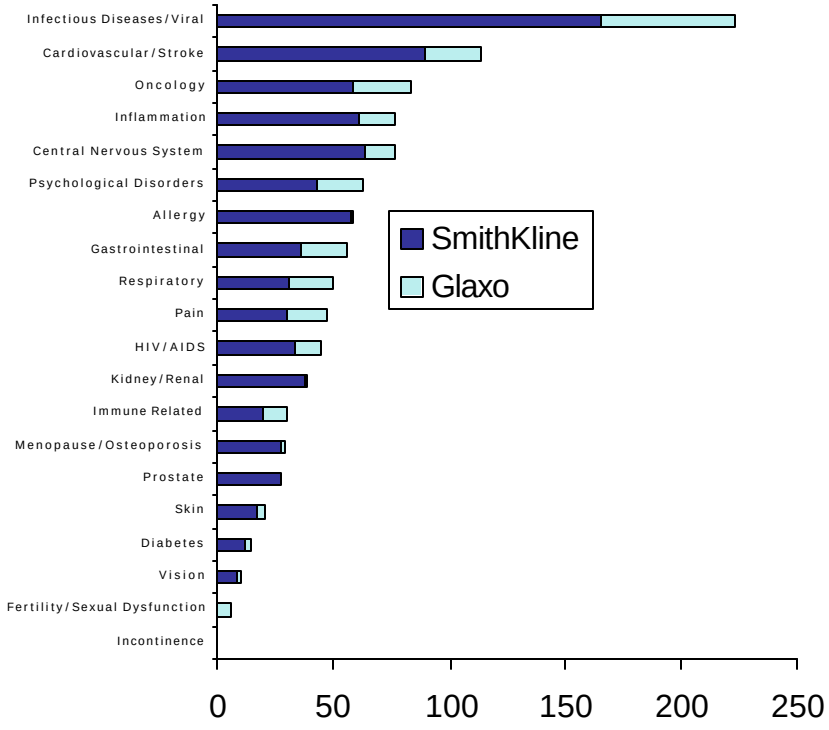
View from 1000 Feet

The two views presented above examine technological quality in general terms. However, in a merger, overall technological quality may be secondary to a particular technology niche. For example, if SmithKline has strong technology in an area in which Glaxo is lacking, this specific strength may be more interesting to Glaxo than SmithKline's overall technological quality.

For this reason it is worthwhile to attempt to categorize the patents into treatment categories. In order to do this, we took the eight pharmaceutical companies' patents and generated a list of treatment keywords based on frequency and proximity to the word "treat*" in the titles and abstracts of the patents. For a discussion of this method of quick categorization, see Breitzman (2000). Twenty-one treatment categories were defined using this approach. Figure 5 shows the number of SmithKline and Glaxo patents in each of these treatment categories[2]. This figure reveals that, for the most part, SmithKline and Glaxo are active in the same areas, although in most cases SmithKline has more patents. Some exceptions are fertility, where SmithKline has no patents, and Glaxo has few; and Allergy, Menopause, Prostate, and Vision, where SmithKline has many patents and Glaxo none. This suggests that by merging with SmithKline, Glaxo is gaining entry into a number of new treatment categories, while strengthening its patent protection in a number of existing areas.

[2] It is also possible to examine the various patent citation indicators for each of the categories. In the interests of space, this analysis is not included in this paper. The point should be made, however, that the indicators are scaleable so that, if desired, one could measure the technological quality of each company at the treatment level in the same way we measured the technological quality of entire company patent sets.

Figure 5 - Complementarity of Merger Partners
1995-99 U.S. Patents by Treatment Category



Summarizing the three levels of analysis presented above, it can be seen that the benefits of the merger become more apparent the closer one looks. At the overall level, it appears that, based on patented technology, Glaxo may be unwise to merge with SmithKline, given the latter's weakness on the three patent quality indicators. At the middle level of detail, SmithKline's large number of biotechnology patents emerges, along with its high quality pharmaceutical patents. These are areas in which Glaxo was previously relatively weak. Hence the wisdom of the merger becomes more apparent at this level. Perhaps the most important of the three levels is the most detailed one, since it provides insights into the specific patenting areas of Glaxo and SmithKline. The analysis at this level reveals that the merger will give Glaxo access to treatment markets in which it previously had little or no presence.

The merger between Glaxo and SmithKline therefore appears to make sense in technological terms, since there is a reasonable technological fit between the companies. This answers the first of the two questions posed at the start of this paper. The next stage is to answer the question of whether Glaxo is paying an appropriate amount for SmithKline under the terms of the merger.

V. Calculating the Appropriate Valuations of Merger Candidates

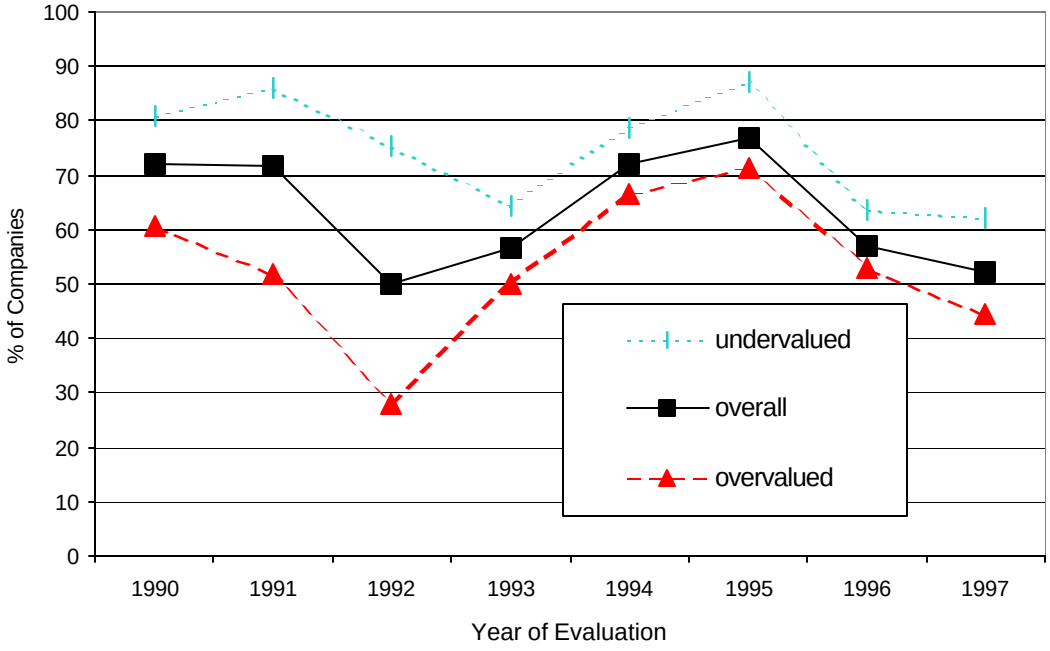
The question of whether Glaxo is paying an appropriate amount for SmithKline was addressed using a methodology previously developed for valuing companies based on the quality of their patent portfolios (Thomas, 2000). This methodology compares a company's actual market-to-book (MTB) [3] valuation with a Tech-Score MTB based solely on the quality of its patent portfolio. Based upon the relationship between

[3] Market-to-book is one of the most commonly used ratios of company valuation. It measures the relationship between the stock market value of a company, and the value of the assets it has on its balance sheet. A high MTB reveals a company that the stock market feels has value over and above the assets revealed on its balance sheet. This value may emerge in part from the quality of a company's technology, which is not explicitly shown on the balance sheet.

the Actual MTB and the Tech-Score MTB, it is possible to define whether a company, based upon its technology, is overvalued (Actual MTB exceeds Tech Score MTB) or undervalued (Tech Score MTB exceeds Actual MTB).

Figure 6 shows the forecasting power of this technique. This figure is based on the idea of defining companies as undervalued or overvalued, and then determining whether their market-to-book valuation two years later has changed in the direction indicated by the model. The market-to-book valuation of undervalued companies should have risen relative to the overall market, while the valuation of the overvalued companies should have fallen relative to the market. The line marked 'Overall' in Figure 6 is a measure of the strength of the stock market. In a strong market, a high percentage of companies experience increased market-to-book valuations, due to increases in their stock price. For example, just over 70% of the companies in the model at the end of 1990 had higher market-to-book valuations two years later, suggesting that the stock market was on an upward trend during that period. However, if these companies are split into two groups - undervalued and overvalued - the forecasting power of the technique becomes clear. Over 80% of the companies defined as undervalued at the end of 1990 had a higher market-to-book two years later, compared to only 60% of overvalued companies.

Figure 6 - Percent of Companies with Increased Market-to-Book 2 Years After Patent Evaluation



This pattern is the same throughout the last decade. At the end of each year, companies are defined as undervalued or overvalued. As Figure 6 shows, each year the percentage of undervalued companies with higher market-to-book valuations two years later is greater than the percentage of overvalued companies with increased market-to-book over the same period. This pattern occurs in strong markets (where a high percentage of companies experience increased market-to-book) and weaker markets (in which a lower percentage of companies experience increased market-to-book). This suggests that the technique is a useful tool for identifying companies that are currently undervalued or overvalued by the stock market.

Table 3 shows the Actual MTB and Tech-Score MTB for the eight largest pharmaceutical companies as of 12/31/99. This figure reveals that Glaxo and SmithKline were trading at $27.37 and $12.40 respectively on

that date. Based on their Tech-Score Prices, Glaxo should have been trading at $6.72, and SmithKline at $3.51. Both companies were therefore overvalued, as were the other six pharmaceutical companies in the study.

Table 3 - Actual and Tech-Score Derived Market-to-book and Share Prices for 8 Pharmaceutical Companies (based on 12/31/99 values)

	Actual MTB	Tech MTB	% Overvalued	Actual Price	Tech Price
Smithkline Beecham*	13.81	3.91	353	12.40	3.51
Glaxo Wellcome*	22.63	5.56	407	27.37	6.72
Merck & Co	11.3	4.05	279	78.63	28.18
J&J	6.35	3.56	178	86.06	48.25
Novartis*	5.31	3.92	135	739.98	546.28
Bristol-Myers Squibb	13.6	3.76	362	66.25	18.32
Amer. Home Prod.	12.47	3.05	409	47.06	11.51
Pfizer	16.11	3.64	443	36.19	8.18

*American Depository Receipts (ADR) Values are converted to actual shares for this computation. (e.g. one SmithKline ADR is 5 shares).

Given that the proposed merger between Glaxo and SmithKline is to be based on a stock swap, the interesting issue is the relationship between the Tech-Score valuations of the two companies. Table 3 shows that, in terms of the quality of their patented technology, one SmithKline share is worth 0.5223 ($3.51/$6.72) Glaxo shares. Under the terms of the merger, each SmithKline share is valued at 0.4552 Glaxo shares. This suggests that, while both companies were overvalued in the stock market on 12/31/99, Glaxo was more overvalued, and was therefore able to purchase SmithKline shares at a relative discount. Hence, based upon the relative quality of their patent portfolios, Glaxo did not pay too much for SmithKline. It paid too little.

VI. Additional Techniques not Discussed

There are a number of additional patent analysis techniques that are beyond the scope of this paper. These techniques should be considered as part of any merger analysis. One major consideration when examining a merger (or in any analysis of the competitive strength of a company) is personnel. Narin and Breitzman (1995) showed that the top 10% of inventors are 3-4 times as productive as average inventors. It is therefore important to identify the key inventors in each of the companies, and determine whether they will be part of the merged company. Another extension to the analysis that should be mentioned is an expansion to global patent families. This analysis used US and EP patents, but can easily be extended to patents of other countries as well as to global patent families[4]. There are a number of additional indicators that can be applied to patent families that are not discussed in this paper. Finally, we have not mentioned anything about the legal status of the patents we analyzed. A more detailed analysis may include a study of whether the patents have been maintained, or allowed to lapse due to failure of payment of maintenance fees.

VII. Conclusions

Since sales depend on products with limited life spans, the future sales of a company depend on its ability to innovate and to continually add products to its pipeline. Thus for technologically dependent companies in many industries (telecommunications, semiconductors, pharmaceuticals etc.) measuring the quality of their technology may be as important, if not more important, than the assets on their balance sheets.

[4] A patent family is a set of related patents filed in a number of countries, but representing a single invention.

This paper has shown that R&D spending is not necessarily a valid assessment of the technological strength of a merged company. Patent analysis offers a much more refined view of companies' capacity to innovate. Using patent analysis, we revealed that, while the R&D spending of GlaxoSmithKline would be nearly double that of Merck, in many ways the combined company will be technologically weaker than Merck. However, the quality of Glaxo and SmithKline's technology has shown a great improvement in recent years. The paper has shown that, by merging with SmithKline, Glaxo will improve its patent portfolio in pharmaceuticals and biotechnology, and gain entry into new treatment areas. The paper also presented a new method for estimating the value of a company based on the quality of its patented technology. Using this patent based pricing mechanism we showed that, while both Glaxo and SmithKline are overvalued in the market, Glaxo is still getting SmithKline's technology at a relative discount.

The techniques introduced in this paper are designed for use in any technology-based industry. The example in this paper was selected because of the large amount of publicity that the GlaxoSmithKline merger has attracted. The same techniques may be used to assess other mergers, in order to provide insights into the technological fit between the companies involved, and to value the companies based upon the quality of their patented technology.

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